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Industrial Water Treatment as a Distribution System Hazard

By C. K. Calvert

IT is the business of the producer and distributor of water for domestic use to deliver it to the customer in good condition, not alone from the standpoint of taste and odor, but also bacteriologically. Means are available for the production of a safe water, so far as disease transmission is concerned, and the control of taste and odor is becoming better understood. Water leaving a purification plant may be, and generally is, satisfactory; yet it may be delivered to customers in an unsatisfactory condition because of factors not under the direct control of those in charge of purification or distribution. For too long, customers have been allowed to make connections to the public water supply, with no questions asked regarding the use or treatment of the water to be supplied and the effect such treatment may have on its safety or salubrity.

It is becoming increasingly apparent, to those who investigate reports of water troubles, that persons engaged in industrial plant maintenance and operation cannot always be trusted to regard drinking water systems with respect. If water is needed for some particular operation, a connection may be made to the public supply even though such a connection will be actively or potentially dangerous. If a sewer line is flat and clogs easily, a booster jet may be installed to operate with water from the public supply, with no attempt to prevent back-flow.

Any operation within an industrial plant or any condition in the distribution system itself which causes or permits a reversal of the normal flow of water into the premises may result in contamination which is objectionable or actually dangerous. The reversal of flow may result in the entry of objectionably treated water into the mains, so that the casual user of water on adjacent private property may be adversely affected, to the discredit of the public supply.

When water passes a customer's meter or, in the absence of meters, enters his premises, it is sold to him

A contribution by C. K. Calvert, Supt. of Purif., Indianapolis Water Co., Indianapolis, Ind.

because he has paid or will pay for it and presumably it becomes his property to do with as he wishes, just as in the case of a purchased barrel of salt, a horse or an automobile. But a man may use an acquired thing in an illegal or unethical way. The water department is concerned with this possibility, in the case of purchased water, because such use may actually affect, or reflect on, the quality of the water distributed for general use.

After entering a customer's property, subsequent contamination of the water is clearly the responsibility of the new owner. It happens, however, that any complaint regarding water is not necessarily directed toward the last owner but may be toward the producer of the water, who is held responsible in the minds of most persons. Thus, as a matter of his own protection, as well as for the protection of the public health, it becomes necessary for the producer and distributor of water to know something of the uses to which it is to be put and the means of handling it after it is delivered to a customer.

Either cross-connections between a potable and a contaminated supply or back-siphonage from toilet fixtures or manufacturing process may render the water in a private or public distribution system unfit for use as drinking water. The conditions under which these means may affect water quality are substantially the same as those under which planned treatment by a customer may become important to the public health and convenience.

Supplemental corrective treatment of the public water supply on users' premises is necessary in some cases to reduce deposition or corrosion (as the case may be) in the interior piping system, or to render the water more suitable for special process use.

To protect the users of water for drinking purposes and consumers of food containing it, it is worth while to lay down certain rules which should govern the handling of water when supplemental treatment of the public supply is required.

If the treated water is to be used for human consumption (either in food prepartion or directly as a beverage) great care is necessary to: (1) prevent bacterial contamination of the water; (2) avoid the use of poisonous chemicals; and (3) avoid the addition of excessive amounts of chemicals, which are harmless in concentrations effective in obtaining the desired results.

Miscellaneous water treatment is so difficult to control that it should be discouraged. Suitable treatment may, in most cases, be applied economically at the municipal purification plant, resulting in greater uniformity and avoiding conditions injurious to health. Where supplementary treatment of water is unavoidable, it should be applied only with the approval of the public health agency having jurisdiction.

No compounds which are poisonous or injurious should be used, either alone or mixed with harmless chemicals. Permissible compounds are sodium silicates, sodium carbonate, sodium bicarbonate, sodium hydroxide, sodium phosphates, calcium carbonate, calcium bicarbonate and calcium hydroxide. None of these chemicals should be added in such amount as to produce causticity or to increase the total alkalinity, total hardness or total silica content of the water by more than 50 ppm.

For the protection of pipelines and general equipment coming into contact with water, it has been found that certain metallic salts are effective in

some waters. One example is chromium compounds. These salts are poisonous when taken into the human digestive tract. They do not make themselves apparent to the casual user of the water. If an industrial water distribution system must be protected by the use of such compounds, that system *must* be separated from drinking water lines just as carefully as if the water contained in it were contaminated bacteriologically.

Proper Storage for Chemicals

The stock of treatment chemicals must be stored in such a way as to preclude the possibility of contamination or tampering by unauthorized, careless or vicious persons. The chemicals in the feeding device require as careful protection as those in stock storage. When feeding devices are of the solution type, the concentration of chemicals in the stock solution should be high in order to obtain all possible bactericidal or bacteriostatic action during storage of the solution prior to actual use. Otherwise multiplication of bacteria may take place and contamination of the treated water.

The chemical feeding device must be of good construction and must be capable of delivering the required amount of chemicals with accuracy. Regardless of toxicity, even moderately high concentrations of otherwise suitable compounds may be nauseating or injurious. The amount of chemicals added to the water must be as small as possible to produce the condition necessary of attainment. The feeding device may be operated by an intelligent, but technically untrained, person after thorough instruction. The prescription of treatment for a water must be made only by a chemist or engineer with at least five years experience in water chemistry or treatment. At least monthly chemical examinations should be made of samples of the treated and untreated water to determine: (1) the necessity for continued treatment and (2) the effectiveness of the treatment.

In food handling, preparation or packing, the process water coming in contact with the product, or being included with it in the package, should be subject to the same provisions as apply to water for drinking.

It has been proposed that water for drinking purposes in large establishments be treated with sodium chloride during the warm months to obviate the necessity for individuals to take the salt tablets generally provided where temperatures are high. This is properly considered to be a corrective water treatment and should come under the provisions included herein. The salt added to the water for this purpose is rather small in amount and will tend to increase bacterial growth rather than retard it. When such treatment is given, the salt solution in the feeding device should be as concentrated as possible to reduce the rate of bacterial growth before the solution is added to the water. The fact that the addition of salt to all of the drinking water is included herein as a supplementary water treatment process does not mean that the plan is unreservedly approved. In fact quite the contrary is the case. Such addition may be objectionable to some and to many people in some occupations. It should not be used except on the advice of qualified experts.

In many cities, acetylene plants in industrial establishments have been so operated as to develop higher pressures than are usually carried in public distribution systems. The solution from such plants may not cause illness or death, but is highly offensive in drink-

ing water. For this reason, these plants should come under the provisions of the regulations affecting supplementary water treatment.

In soda fountains and drug stores, the public supply is used generally for making carbonated water. Usually, only a single check valve is placed between the drinking water supply and the carbonated water. In the experience of many water plant operators, complaints have been received of tastes in the drinking water in such establishments and, occasionally, carbonated water has been forced back into the general distribution system with adverse customer reaction. All establishments using the public supply for carbonation should come under the provisions of the regulations affecting supplementary water treatment.

Distribution systems in some large industrial and office buildings have become seriously clogged with deposits derived by corrosion of the pipe by the water furnished for public use. It has been found that acid, containing inhibitive agents, is effective in removing the deposits and increasing the carrying capacity of the pipe. There is great danger that these acid solutions may be drawn back into the distribution system in the event of sudden reduction of pressure. When this type of treatment is given to internal piping systems, they should be separated physically from the general water system and supplied with water by a special pump for chemical application and subsequent flushing. Before the private system is reconnected to the public supply, chemical tests must be made to show that the chemicals used in treatment are removed completely.

Some waters attack some metals to such an extent as to affect the health of the users of the water. The producer of a public water supply should and does see that the water delivered into his distribution system is of such character as to produce no dangerous reactions with the material of which the distribution system is constructed. It is, obviously, the responsibility of the water customer to see that his own distribution system is made of a material which will not react adversely with the water in the public supply. When inferior piping is found in a private distribution system, that system should be treated in the same manner as if supplementary water treatment were applied. If a change is made in the character of the public supply which renders previously safe metals dangerous, however, the responsibility plainly lies with the water producer unless due general notice has been given to the owners of private supplies advising them concerning the specific change which has been made and of the probable effect on customary pipe materials.

Private Filters

The use of private filters for the removal of objectionable solids in the public supply concentrates such solids on the surface of the filters. A backflow into the general distribution system may concentrate these solids in a rather small amount of water and cause an objectionable condition. Such filters, therefore, come under the provisions affecting supplementary water treatment. In hard-water districts zeolite water softeners are used to provide soft water for certain industrial uses. Business establishments employ them frequently. If a negative pressure should occur at the time of regeneration of zeolite softeners, strong brine solutions may be drawn back into the distribution system. To pre-

vent this occurrence, plants larger than those used in single dwellings should be considered as coming under the provisions affecting supplementary water treatment. The amount of brine which might be drawn back from a household-size softener is generally too small to be objectionable.

In many places the practice of adding water to low-pressure heating boilers directly from the water supply is followed. Under certain conditions, hot water (perhaps containing a concentration of chemicals in solution or suspension) may be forced back into the service lines on the customers premises or even into the distribution system itself. When boilers for heating or other purposes are directly connected to the water service lines, the service should be considered as coming under the provisions affecting supplementary water treatment.

It has come to the writer's attention that in severe climates anti-freeze liquids and solutions are used to some extent in sprinkler systems during the winter. Some of the substances which have been used are toxic and all are objectionable in water for human consumption. It is perfectly obvious that no poisonous substance should be used for such a purpose. The service supplying such a system should be considered as coming under the provisions affecting supplementary water treatment. The best means of preventing freezing in exposed sprinkler piping is to use the dry system.

Corrective Treatment

Certain manufacturing and process industries present unusual hazards, and, although the water they use is not necessarily given supplementary treatment, it may be well to call attention to the need for similar protection of their service lines. Sewage disposal, garbage and refuse, rendering, slaughter and organic fertilizer plants are types whose service lines should be equipped in the same manner as if supplementary water treatment were applied.

Wherever water is given supplemental corrective treatment by users, a system of double check valves and gate valves should be placed at the meter on all service lines from the public supply. The protective valve system should consist of two gate valves between which are placed two check valves, at least three feet apart. For lines three inches in diameter and under, the check valves should be brass or bronze with renewable composition cold-water discs. For lines larger than three inches in diameter "Factory Mutual" type all bronze rubber-faced check valves or approved iron-bodied bronze or brass-mounted rubber-faced check valves should be used. Outside screw and yoke rising stem gate valves are preferable.

To be able to test the functioning of the check valves, a petcock and connection for a pressure gage must be provided close to each check valve and on the side nearer the service line from the public water supply. The protective valves must be located in a basement or outside frost-proof pit and must be accessible for inspection and test at all times. Routine testing of the check valves should be made twice each year and faulty operation should be corrected at once. The design of the check valves and their exact arrangement must meet the approval of the State Sanitary Engineer.

It is recognized that check valves are mechanical devices and as such are subject to failure which may come suddenly. The life of check valves

and the suddenness with which they fail are more or less in proportion to their quality. For this reason only approved types and makes should be installed. When high quality valves have been installed, experience has shown that more than very small leaks occur very infrequently.

In some states, at least, prohibtion of cross-connections between a private and public supply has resulted in the existence of secret cross-connections. Certainly all cross-connections should be prohibited, but it is not enough for authorities, either public health or public water supply officials, to prohibit such connections. They must also *prevent* them from affecting the public water supply insofar as is possible.

In addition to prohibiting cross-connections, a regularly inspected system of check valves adds safety to the situation. Summarizing the figures presented by E. Sherman Chase,* it is found that in 29 of the more than 13,000 inspection cases cited, both checks were found leaking. Nineteen such failures occurred in one state in a single year, which suggests that there may be some special explanation with respect to them. At any rate, the low percentage of failures recorded lends strength to the recommendation of the double check valve plan—provided that the valves are of good quality and inspected twice a year.

Sometimes, when a water customer treats only part of the water in a manner which renders it unsuitable for drinking or for use in food products or beverages, he installs check valves to prevent a back-flow into potable water lines. In such cases, the customer's intent is good, but it must be remembered that uninspected or untested check valves may fail. Similarly, improper piping connections are so easily made within a manufacturing plant that it is considered necessary to protect the service lines at the meter so that no accident may result in the contamination of the water in the public distribution system. This measure is taken in addition to the check valves a customer may install for his own protection.

The enforcement, by a water department, of rules designed to protect users of water from the effect of supplemental treatment carries with it no responsibility for the adequacy of such measures or for the result of their failure to function as intended. The water department is in the position of protecting its customers, casual water users and itself as best it can and no responsibility can be placed upon it for the acts of any customer which may affect water quality within or without his own premises.

* Present Status of Cross-Connection Control. Jour. A.W.W.A., 32: 1737 (1940); *see* Table 2, p. 1750.

The Need for Practical Standards

By R. F. Goudey

THE expanding federalization of drinking water control, the great increase of wartime abuses in the use of domestic water systems and the phenomenal development of protective devices against back-flow makes desirable a clear conception of the degree to which ideal drinking water standards will actually be put into practice. Health officials have failed in their attempt to reserve drinking water systems for drinking purposes only. The day of avoiding all cross-connections has passed. The time has arrived for the health official to put his foot down on mounting incorrect uses of water and to take a definite stand against some of the newer hazards brought about by war conditions. The old standards have been successful in reducing the now rare water-borne diseases of typhoid, paratyphoid, dysentery and cholera to the point where medical students are unable to obtain clinical experience. The new Public Health Service Drinking Water Standards (1) will be helpless to cope with present-day conditions unless the American Water Works Association squarely faces the new issues.

Increasing Federalization

Federalization of water supply supervision is expanding. Only by making the new Drinking Water Standards more practical by the help of the American Water Works Association participation can the water works operator be given a fair break.

At first, the U.S. Public Health Service exercised its quarantine power at ports to include supervision of ship water supplies. About thirty years ago the Interstate Commerce Commission delegated commerce powers to the U.S. Public Health Service to regulate water supplies used on interstate carriers. Although some operators have been asked to submit water analyses to their state boards of health, the entire procedure has been dealt with in a secretive and confidential manner, the operator never knowing when or to whom his supply has been certified. Some state health departments have been using the federal standards for all their supplies regardless of whether the water was used on ships or interstate carriers.

With the creation of the Federal Security Agency and absorption of the

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A portion of a discussion prepared for and presented in a symposium on the U.S. Public Health Service Drinking Water Standards (*see* p. 1409 of this JOURNAL) on June 18, 1943, at the Cleveland Conference by R. F. Goudey, San. Engr., Dept. of Water & Power, Los Angeles. This portion of the discussion is published here as a separate article to facilitate its study in relation to the article "Industrial Water Treatment as a Distribution System Hazard," by C. K. Calvert, immediately preceding.

U.S. Public Health Service in it, the latter was given power through the Office of Civilian Defense to increase its functions and expand its personnel so as to have specific supervision in an advisory way over all water supplies.

Prior to 1937, the U.S. Public Health Service was authorized to make a spot survey of cross-connections in federal buildings. A most excellent illustrated report (2) dealing with public health hazards in plumbing was released. Water works men can, and rightly so, expect to be asked to clean up cross-connections and faulty plumbing.

Other federal agencies are now expecting water supplies to meet federal standards not only for water, but also for plumbing. In 1938, the National Bureau of Standards issued an excellent report (3) on plumbing standards. These recommendations are now invokable by the U.S. Public Health Service. Housing projects using the emergency plumbing standards, approved by the President of the United States in 1942 (4), require local authorities to avoid all sanitary defects relative to cross-connection and backflow conditions and even require eight copies of bacteriological summaries to see if the supply compnies with federal standards before a project can start. The new regulations of the Coast Guard, approved by the President of the United States in 1943 (5), and dealing with the "Security of Vessels in Port," specifically require co-operation of municipal officers (which, in this case, includes water works operators) to work with ship authorities to safeguard their water supply at the dock. Every military detachment or post within municipalities requires water works operators to furnish, on forms provided for the purpose, chemical and bacteriological data (where the information is available) on the basis of which they may evaluate the supply according to the federal standards.

The need to get down to brass tacks so far as practical standards are concerned, is evident; otherwise, cases of arbitrary interpretations in the field will create embarrassing situations.

Wartime Tendencies

Wartime trends have increased sanitary defects and health hazards. The use of drinking water systems for drinking water only has been violated by policies of the War Production Board in prohibiting, in many cases, the use of critical materials for such purposes. In some instances, domestic lines have been converted into joint industrial and domestic lines and, in others, they have been connected with dual sources of supply to satisfy newer clamors for increased fire protection. Management of industrial plants has jeopardized the safety of water supply to increase production. In one plant, for instance, a worker, on finding the drinking water salty, is expected to spit out the polluted water and return later when he may find the supply fresh.

New policies in regard to ship water systems endanger municipal systems. Every ship at dock is required to have a fire line under pressure on board. This requires more shore connections than previously. Ships which formerly carried several hundred men to sea for a few weeks' duration are now carrying 900–2000 men and remain at sea for four to six weeks at a time. Ballast tanks are used for fresh water and salt water pumps must be used to transfer water from one tank to another. New ships properly fitted at

shipyards at the time of their construction are re-piped at sea to meet these operating conditions.

Defense plants are now using a wider variety of poisonous substances (particularly in plating operations) in ways which might easily cause back-flow into the water system. New and unique devices for using water, which constitute inter-connections are being employed. In many cases, expansion of plant facilities has overloaded the water system to the point of creation of partial vacuums in the private distribution piping systems.

It would be difficult to ascertain a true picture of present conditions throughout the country but, from a limited knowledge of what is occurring in the West and Southwest, it is evident that standards must be made practical. For instance, in Los Angeles where a most progressive campaign against cross-connections has been waged for fourteen years, inspections made in defense plant and military areas during the past six months revealed the existence of over 10,000 cross-connections. While some of these cross-connections were plumbing hazards, the preponderance were even more serious due largely to the feverish rush to provide defense and military facilities following the declaration of war. In five widely separated areas on the Pacific Coast, during the past six months, eighteen known instances of water supply pollution from cross-connections and/or inter-connections have involved thousands of shipyard, airplane and military personnel, causing not only the actual loss of several ships and of many bombers, but also impairing the health of the workers and increasing involuntary absenteeism. A number of the cases involved pumping of salt water from ships into yard systems and back again into the drinking water supplies of the boats themselves. In two cases, ships so affected were notified at sea to take precautions for water so obtained.

Development of Protective Devices

Progressive development of check valves has resulted in their meeting higher specifications and in providing attachments to satisfy partial vacuums and to destroy excessive property pressure passing a primary check valve, so that a broken connection automatically exists when use of water ceases or back-flow conditions arise. Protective units are now available for small services. Such devices have a practical application. In this respect, it should be noted that the U.S. Public Health Service, as early as 1930, directed state boards of health to adopt specifications and approval procedure for modern back-flow preventive devices, but this task still remains to be done.

Management in Southern California industry now knows that it pays dividends to keep water supplies safe from back-flow pollution and is ready to install back-flow preventive devices. In the absence of nation-wide specifications or lists of approved devices, management feels that someone has been lax in his duties.

Practical Details

It is quite proper to set up ideal standards and strive for mathematical accuracy so far as bacterial results are concerned, but, somewhere in the sequence, definite policies must be formulated to cover such points as:

1. Improper uses of water
2. The circumstances under which back-flow protective devices may be employed

3. Distribution system sanitary defects which should be corrected.

4. Methods of protecting siamese connections, when installed on domestic water systems

5. Methods of protecting fire lines having yard or pier-head connections approved by the National Board of Fire Underwriters, when furnished with water from the public drinking water system.

Extension of Responsibility

Water works operators usually feel that their jurisdiction terminates at a property line or meter. In 1941, Moore (6) indicated that this is no longer true. Under Sec. 1.6 of the revised Drinking Water Standards (1), the water works operator definitely becomes responsible for the safety of the water supply from the source to the free-flowing outlet of the ultimate consumer. This requirement is based on the fact that interruptions of street main service from breaks, shutoffs, fire pumping or sufficient drops in pressures in hilly areas might draw pollution from private premises out into street mains and, on resumption of normal pressure, force such pollution into adjacent services. Some operators have already provided back-flow protection at the meter for particularly dangerous service connections. This leaves the health authorities responsible for the safety of the piping system within such premises.

Water works operators are now duty bound to shut off all affected services when street mains are shut down for repairs, to provide air inlets in hilly territory to minimize vacuums when mains break or are drained and to provide back-flow protection on particularly dangerous water services. Within private premises, water works operators should establish co-ordination with health and building departments in order that appropriate police power may be invoked when necessary. Rules and regulations of all water departments should include the right to enter private premises on reasonable notice, to make inspections and to discontinue service if violations persist.

In Los Angeles, the Cross-Connection Control Advisory Committee was created by joint action of Health, Building and Safety and Water Commissions and the Board of Mechanical Engineers to determine policies of water supply safety, to eliminate sanitary defects, to employ inspectors with proper deputization and to effect compliance with city ordinances and state resolutions pertaining to water supply safety. This pattern might be followed elsewhere to advantage. The wider responsibility of water operators must be met.

References

1. Public Health Service Drinking Water Standards. *1942 Edition.* Pub. Health Rpts., **58**: 75 (Jan. 15, 1943); Jour. A.W.W.A., **35**: 93 (1943).
2. *Public Health Hazards in Plumbing.* U.S. Public Health Service, Washington, D.C. (Dec. 1937).
3. *Cross-Connections in Plumbing Systems.* Research Paper RP1086, National Bureau of Stds., Washington, D.C. (Apr. 1938).
4. *Emergency Plumbing Standards for Defense Housing.* Div. of Defense Housing Co-ordination, Exec. Office of the President, Washington, D.C. (Feb. 1942).
5. *Regulations for the Security of Vessels in Port.* U.S. Coast Guard, Washington, D.C. (Jan. 1943).
6. Moore, Robert E., Jr. Legal Aspects of Cross-Connection, Inter-Connection and Back-Flow Protection. Jour. A.W. W.A., **33**: 495 (1941).

The U.S. Public Health Service Drinking Water Standards

By F. H. Waring, G. D. Norcom, R. F. Goudey, C. K. Calvert, C. R. Cox and J. K. Hoskins

From the State Sanitary Engineer's Viewpoint—F. H. Waring

In studying the new U.S. Public Health Service standards for water quality, it appears that some of the requirements and recommendations are impracticable from the viewpoint of the state sanitary engineer and, in turn, from that of the laboratories, such as those of municipal water purification plants, under his supervision. While the impracticability is not insurmountable, it does seem that certain of the changes made in revising the standards do not have sufficient merit to overcome the obstacles of putting them into effect.

In discussing the various items, reference will be made to the enumerated sections of the standards, as published in *Public Health Reports* and in the JOURNAL.[1]

Bacteriological Quality

Standard Portions and Standard Samples: In Secs. 1.8 and 1.9, the reporting agency is given the option of examining, as a "standard portion," either 10-ml. or 100-ml. quantities of water. Likewise, in Sec. 1.9, it is noted that the "standard sample" may consist of either five standard portions of 10-ml. or five standard portions of 100-ml. quantities. The embarrassment of changes in equipment necessary to run standard portions of 100 ml. are many. State laboratories and water works laboratories would have to purchase extensive new equipment, such as sample bottles, pipets and fermentation tubes, to perform analyses on the 100-ml. portions. New incubators of larger space to accommodate the large samples might also be necessary. The sampling bottle would have to be greater than 500 ml. in capacity to accommodate the taking out of five standard portions of 100 ml. each. Extra cost for media is still another factor. It would seem that the refinements in the accuracy of the coliform index would not warrant the added expense above indicated, although there

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A symposium presented on June 18, 1943, at the Cleveland Conference by F. H. Waring, Chief Engr., State Health Dept., Columbus, Ohio; G. D. Norcom, Cons. San. Engr. & Chemist, New York; R. F. Goudey, San. Engr., Dept. of Water & Power, Los Angeles; C. K. Calvert, Supt. of Purif., Indianapolis Water Co., Indianapolis; C. R. Cox, Chief, Bureau of Water Supply, Div. of Sanitation, State Dept. of Health, Albany, N.Y.; and J. K. Hoskins, Sr. San. Engr., U.S. Public Health Service, Washington, D.C.

[1] Pub. Health Rpts., **58**: 75 (Jan. 15, 1943); Jour. A.W.W.A., **35**: 93 (1943); reprints available from Superintendent of Documents, Washington, D.C., by requesting Reprint No. 2440, price 10 cents.

is no denying the fact that testing 100-ml. portions does give more accurate results.

Criticism of permitting an option to be exercised as to whether 100-ml. or 10-ml. portions make up the standard sample occurs to the writer. For example, persons desiring to embarrass the reporting agency could deliberately use 100-ml. portions for the standard sample to obtain results that could be construed by the public as being at variance with the results obtained by the regular reporting agency using 10-ml. portions. This is especially true if single or only occasional samples are taken instead of a routine series of samples. Obviously, such a procedure would be unfair, but it could legally be used by an unscrupulous person trying to embarrass the local administration of a municipal water supply system. To the writer, it would seem better to say that the official standard portion shall be 10 ml., although no objections will be offered to using 100-ml. portions in the interest of greater accuracy of reporting a series of results.

Collection of Samples: From study of Ohio practice, it appears that the standards are not being adhered to in many laboratories, including the state laboratories. There are many reasons for the deviations. For example, although every standard sample is supposed to have five standard portions tested, the Ohio state laboratory makes only two standard portions for coliform organism determination. The vast number of samples handled in the state laboratory precludes the running of five standard portions on each sample; either fewer samples must be tested or more equipment must be purchased and a larger personnel of technicians must be employed.

The same comment is true with respect to some water works laboratories. Many operators feel that it is more informative in a series of results, extending, say, for every day throughout the month, to make fewer than five standard portions per sample and to make them every day, than to take five standard portions but confine the testing to every other day or every third day. There is merit to this argument in view of the limitations of equipment and laboratory help.

The examination of a sample is supposed to be performed within 12 hr. of the time of collection of the sample and the sample itself is supposed to be kept at a temperature between 6° to 10°C. (43° to 50°F.). This is obviously impossible for the vast majority of samples tested by a state laboratory, where the elapsed time between the collection of samples and analysis is a minimum of 24 hr. and more often 48 hr. The Ohio laboratory long since abandoned efforts to maintain the temperature control of the shipped samples, because of practical impossibilities of guaranteeing the temperature as well as difficulties with handling the extreme bulk in making the shipments. There would be no excuse for a local laboratory, such as a water works, not being able to comply with the time and temperature factors of the requirements of the standard.

It has not been the Ohio State Health Department procedure—and the writer understands it is likewise not the practice in many other state laboratories—to de-chlorinate all samples as collected and prior to shipment to the state laboratory for examination. There is no reason why this could not be done, although there is some question as to the need for doing so.

The foregoing comments are not intended to subtract from the refinements of sample collection in order to give accurate bacteriological data upon water samples as of the moment the sample was collected. The impracticability of complying with all of the requirements should, however, be recognized. Perhaps this can be done in interpreting the results of analysis.

In addition to the foregoing, attention is invited to the need for the careful training of the collector of samples, so that errors, far greater than procedural errors in the analysis, can be avoided. It has been the writer's experience that interpretation of results of analysis depends more upon care that has been exercised in the sample collection by the collector himself than upon numbers of portions tested, sizes of portions, time and temperature of shipment of containers and the like.

Minimum Number of Samples: In Sec. 3.1., there are set forth provisions regarding frequency of sampling and location of sampling points, both with respect to determining representative information for water in a distribution system. The recommendation set up for a minimum number of samples per month for cities of various sizes appears reasonable, provided, however, that the water analysis is being done at the local laboratory. The writer has difficulty in determining whether the frequency is a recommendation or a requirement; i.e., whereas the terminology of the third paragraph is "*should* be," that of the footnote is "*shall* be."

Of course, many cities do not treat the well water served. In these cases, laboratory facilities are rarely available for the frequency of testing water in the distribution system indicated in Sec. 3.1. The reporting agency, i.e., the State Department of Health, would have great difficulty in convincing such a city that a local laboratory, with facilities to make these frequent tests, should be provided. City and state laboratories cannot undertake the volume of work entailed by such a recommendation or requirement. The writer estimates that, of the 94 cities having separate water supply systems in Ohio, probably 20 do not treat the supply in any way and have no local laboratories through which this recommendation or requirement could be met. In such cases, the reporting agency will have great difficulty in certifying or in reporting to the certifying authority, if the requirement is mandatory.

Physical and Chemical Characteristics

Section 4.1, describing physical characteristics, remains unchanged—still providing that the turbidity of the water shall not exceed 10 ppm. The writer has always been skeptical of permitting any turbidity, especially in treated surface waters. Certainly no visible or perceptible turbidity should be considered excusable in water treatment practice. On the other hand, the limitation of a color standard of 20 ppm. seems somewhat beside the point, provided that the water meets the bacteriological standard and does not exhibit taste or odor. In some cases, hardship may be experienced in attempting to reduce color of some surface waters to less than 20 ppm. at all times. It seems to the writer that the appearance of the water is of less significance than its turbidity, especially in considering surface waters subjected to purification processes.

In Sec. 4.21, reference is made to a limitation of fluorides to 1.0 ppm. Based upon experience in Ohio, backed

up by careful dental surveys, it would seem that this upper limit is not high enough. In other words, waters with at least as much as 1.5 ppm. might be considered unobjectionable from the viewpoint of possible effects upon tooth and bone structure. Actually, in Ohio, no concern is felt, and no suggestions are made to the municipality that reduction in fluoride be attempted, unless the fluoride content reaches as high as 2.0 ppm. The writer believes that the consensus of opinion of dental experts indicates an upward trend in the desirable and permissible quantities of fluorides in drinking water.

Section 4.22 of the standard has not been changed, providing that iron and manganese together should not exceed 0.3 ppm. It has been the experience in Ohio that 0.5 ppm. is a satisfactory upper limit for these two constituents in combination. This is especially true if the water also contains an appreciable amount of organic matter or if a small amount of sodium hexametaphosphate is added to sequester the iron and manganese. Actually, no concern has been felt until the quantity has reached 0.7 or 0.8 ppm., at which time it has been suggested that the municipality take steps to reduce the iron and manganese. In other words, there are many waters in Ohio which could not meet the standard, but which the State Health Department is willing to declare perfectly satisfactory.

Again in Sec. 4.22, the statement is made that total solids should not exceed 500 ppm. for a water of good chemical quality, but that, if such a water is not available, total solids of 1000 ppm. may be permitted. It seems to the writer that it would be much more satisfactory to word the statement the other way around; i.e., that the total solids should not exceed 1000 ppm., and preferably not exceed 500.

Apparently in the last part of this section an attempt is made to put limitations upon the lime-soda process of water softening. Three distinct limitations are indicated: a limit upon total alkalinity; a limit upon pH, which in turn would limit causticity; and a limit upon the normal carbonate alkalinity that can obtain in such a treated water. To the writer these limitations appear inconsistent and undesirable in view of the fact that no attempt is made to place similar limitations upon natural waters or upon zeolite-softened waters. The writer does not agree with any of the three limitations set up, although they may indicate good practice in lime-soda softening. Experience in Ohio indicates that the limitations are exceeded in many lime-soda softening plants, which, the writer still believes, produce waters of good chemical quality.

From the Plant Group Viewpoint—G. D. Norcom

In presenting this discussion of the U.S. Public Health Service Drinking Water Standards from the point of view of a group of smaller water works plants, the writer wishes to make it clear that the opinions expressed are not the official point of view of any particular group of plants, but represent his own personal opinion. Fundamentally, there should be little, if any, conflict of opinion on a subject of this kind, regardless of the point of view. In fact, it might well be questioned whether a discussion of the new standards is appropriate at this time in view of the fact that no one has had sufficient experience with them as yet to be entirely familiar with their operation.

The new standard is so written as to take into consideration most of the constructive criticism presented at the 1941 A.W.W.A. Convention at Toronto;[2] and certain of the provisions are a definite improvement on the old standard.

Bacteriological Requirements

The use of standard portions and standard samples of two different sizes is evidently a compromise which permits advocates of either method to follow their own judgment. The designation of the larger standard portion and sample should also prove useful to those normally employing the smaller portion and standard, since the more elaborate procedure can be used for purposes of checking in the case of samples which appear to be on the borderline as to sanitary quality.

It is gratifying that the new standard permits the use of several alternative methods for the demonstration of the presence of the coliform group, thereby making it unnecessary to carry through the so-called "completed test" on all samples examined. The inclusion of liquid confirmatory medium has been so satisfactory in practice that its inclusion in the standard represents definite progress.

In discussing the standard with others, the writer has found a considerable difference of opinion concerning the desirability of that provision of the standard which requires that samples from any disinfected supply be freed of the disinfecting agent within twenty minutes of the time the sample is collected. Some workers take the view that the water utility does not de-chlorinate the water which is delivered to consumers and that, therefore, there is no reason to de-chlorinate the samples. The fallacy of this argument is too clear to require discussion; nevertheless, it should be mentioned that, in many instances, chlorinated water reaches the consumer within five minutes of the time of application of chlorine and it is the quality of the water at the end of this five-minute period which governs in such an instance.

Protection Against Plumbing Hazards

Concerning source and protection of the water supply, it is felt that the provision that the water supply system in all its parts shall be free from sanitary defects and health hazards is excellent from a theoretical standpoint, but is liable to be difficult of enforcement. For years, authorities have been attempting to rid distribution systems of cross-connections with non-potable water supplies; yet there are few who would venture the opinion that this aim has been accomplished or that it is likely to be entirely accomplished in the near future. The situation is even more difficult in the case of plumbing hazards, because these will occur within buildings where they may remain hidden for years. Needless to say, all water works men are in sympathy with the ideal expressed in this section of the standard; nevertheless, it is interesting to speculate on how complete freedom from such defects can be maintained at all times and just what action the certifying authority is in a position to take until the hazards have, in fact, been completely eliminated.

Sampling Requirements

It is with the sampling provisions that the greatest difficulty with the

[2] Revising the U.S. Standards for Drinking Water Quality. *A Symposium.* Jour. A.W.W.A., 33: 1804, 2215 (1941).

new standard is likely to be experienced. In spite of the opinions which were expressed prior to the enactment of the standards regarding the unreliability of distribution system samples as a continuing satisfactory basis for judgment as to the safety of a water supply, the new standard specifies that all samples to be used in connection with the standard are to be taken from the distribution system. It is granted, without argument, that considerable weight should be attached to the quality of distribution system samples, but almost every public health administrator having to do with the quality of water supplies has experienced instances where coliform organisms have been found in distribution systems and where such findings have persisted for long periods of time when all samples from the source of supply have been negative. Frequently these occurrences disappear as mysteriously as they appear and, in most instances, they are entirely unaccompanied by any increase in the incidence of intestinal disorders.

Most operators of unfiltered water supplies hold the opinion that particles of leaf mold, soil and other harmless materials often enter the distribution system and ultimately find a resting place in the pipe film which is usually present in the mains. Such particles of material are likely to occlude coliform organisms derived from the soil or from other sources totally unconnected with sewage pollution. Whenever the flow in the mains is disturbed, as by a heavy draft or reversal of flow, the pipe film is also disturbed and some of the coliform organisms which have been resting in the pipe mud are dispersed in the water, resulting in positive tests. Operators are also obliged to take into account the reservoirs and standpipes, either open or inadequately covered, through which a considerable amount of wind-blown or bird-carried material containing coliform organisms gains access to public water supplies. Most of this kind of contamination will be found to be harmless upon investigation, yet it results in the occurrence of coliform organisms in distribution system samples. Now this is fact rather than fancy, as demonstrated on numerous occasions, and it raises the important question: "What significance is to be attached to this type of occurrence and what action will the certifying authority take in dealing with water supplies in this category?"

The new standard specifies the minimum number of samples to be collected from distribution systems each month, but provides no modifying clause recognizing the excellence of purification plant performance. It would be assumed, however, that the reporting and certifying agencies intend to evaluate this auxiliary factor in passing judgment on any particular water supply. Compliance with the minimum sampling schedule included in the standard for all the water supplies comprising a group of water companies would involve a considerable expansion of existing distribution system sampling schedules. Many still persist in the opinion that a large number of plant samples must be examined to evaluate the performance of the purification process and that it is going to be necessary to continue this type of control in addition to the schedule for distribution system samples provided in the standard. The total number of samples examined in any one month, therefore, is going to show a very sharp increase in the case of those plants which are supplying water for use on

common carriers. There seems to be no alternative but to make provisions to carry out the additional examinations, even though this may involve the expansion of the laboratory and the increase of its personnel, to say nothing of increased use of gasoline-operated vehicles despite current (1943) orders of the ODT (Office of Defense Transportation) to the contrary.

Physical and Chemical Characteristics

With regard to the physical and chemical characteristics of the water supply, there can be little argument concerning the limitations established by the standard. It is obvious that some latitude will have to be allowed, depending upon the type of water which is obtainable in various locations in the United States.

The "Manual of Recommended Water Sanitation Practice,"[3] which it is specifically stated is not to be considered as part of the standard, represents an excellent compendium on this subject and will doubtless serve as a useful guide to those concerned with water sanitation, just as the material contained in the 1925 Standard has served. The position might be taken that the requirements laid down in this manual tend to represent the ideal rather than the practical approach in many instances, but it is not clear how the committee could have used any other approach. Most operators will strive to attain the ideal, even though the attainment may be difficult, if not impossible.

[3] Pub. Health Rpts., **58**: 84 (Jan. 15, 1943); Jour. A.W.W.A., **35**: 135 (1943); reprints available from Superintendent of Documents, Washington, D.C., by requesting Reprint No. 2440, price 10 cents.

Application of Standards

This discussion cannot be closed without raising the somewhat controversial question of whether these new standards are to be used only in connection with "the administration of the Interstate Quarantine Regulations as they relate to the drinking and culinary water supplied by common carriers in interstate commerce" or whether they are to be considered as a general overall standard to be used in connection with all public water supplies. In the past, the inclination has been to follow the latter procedure—the earlier standards having been recognized as an overall standard of quality. In the case of the new standards, this approach is likely to be much more difficult, because the new bacteriological standard is a "double standard" and questions will arise as to which of the two procedures is to be preferred.

Of greater significance is the requirement of the new standard that the quality of the water is to be judged entirely on the results of the examination of distribution system samples. Since water works men are fully aware of the fact that many distribution systems will fail, at times, to pass the standard, whereas water delivered from the plant is likely to pass the same standard without difficulty, it would appear that an administrative problem of some magnitude is sure to occur in deciding what action is to be taken with regard to such distribution systems. In the case of an unfiltered surface supply with a long record of hygienically satisfactory water, it would appear that nothing short of the construction of complete filtration works would be involved in ascertaining that the distribution system will at all times comply with the bacteriological standard. Regardless of the source of the

water or its treatment, it may be necessary to cover many open storage reservoirs in order to secure these results, even though the reservoirs may not be of such a nature as to permit construction of a proper type of cover. Without elaborating these examples, it will be clear that strict compliance with the standard is going to run head on into the economic question of whether or not it is necessary to construct these elaborate works and of how such construction is to be financed.

Finally, there remains the question of providing the necessary laboratory facilities and personnel to examine the number of distribution system samples that would be necessary in a group of plants or for a large number of sources of supply, if the standard is to be applied as an overall standard of quality. In a group of small- to medium-sized plants, only a few will normally supply water to interstate carriers; and existing facilities will probably be found adequate to handle the number of samples involved for this small number of plants.

From the Operator's Viewpoint—R. F. Goudey

THE new U.S. Public Health Service Drinking Water Standards represent a marked improvement over previous standards. They provide a better recognition of causes behind back-flow in distribution systems and of some of the more important sanitary defects. Although there is some need to amend the standards further, the immediate problem is that of bridging the gap between the ideal of the standards and a sensible practical solution in the field. The water works operator is caught squarely in the middle, with a set of standards which technically cannot be met and with no way of knowing just what improvements need actually be made so that his supply can escape condemnation. Rock-bottom policies of distribution system safety must be formulated. Revision of bacterial standards is inevitable. Specifications for back-flow preventive devices are necessary. It is well, therefore, that the water works operator become fully aware of the significances of the new standards, particularly under present wartime abuses of distribution system safety.

It is not the writer's intention to discuss the many controversial and seemingly prejudiced recommendations contained in the "Manual of Recommended Water Sanitation Practice," which accompanied the standards. The compulsory chlorination of all supplies to carry residuals to the ends of the distribution system, the roofing of all distribution reservoirs and the relaying of sewer or water mains to secure fixed distances of separation may have a narrow application, but these matters are secondary to such real issues as: "What is going to be done with water services to sewer flushing tanks?" and "What is going to be done with siamese fire connections?" [4]

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[4] EDITOR'S NOTE: Several pages of discussion under the heading "The Need for Practical Standards," originally presented by the author in this context, have been removed from their original position and are published in this JOURNAL (p. 1405) as a separate article. Although these comments, covering principally the elimination of cross-connections and protection against back-flow, have a definite relationship to this discussion of the U.S.P.H.S. Drinking Water Standard, it is more important that they be studied in connection with the article "Industrial Water Treatment as a Distribution System Hazard," by C. K. Calvert, which they now follow.

Sanitary Defects

Much stress is placed on sanitary defects in the portion of the standard dealing with "Source and Protection." Section 2.2 states: "The water supply system in all its parts shall be free from sanitary defects. . . ." The term "sanitary defect" is defined in Sec. 1.4 as: "any faulty structural condition, whether of location, design or construction of water collection, treatment or distribution works, which may regularly or occasionally cause the water supply to be contaminated from an extraneous source, including dual supplies, bypasses, cross-connections or inter-connections (back-flow connections) or fail to be satisfactorily purified." There is not a single water system free of all cross-connections and plumbing hazards, let alone other types of sanitary defects mentioned in the manual accompanying the standards. The letter of adoption and approval introducing the new standard states that it *"must be complied with"* to obtain certification. Further, the Advisory Committee recommended that definite failure of a supply to meet any of the sanitary, bacteriological and chemical standards constitutes rejection of certification or issuance of a provisional certificate. This is a dilemma.

In the past, the U.S. Public Health Service could certify a supply if the bacterial standard was exceeded, but if a rigid inspection indicated the supply to be safe. On the contrary, if an inspection of the supply indicated contamination likely, even if the bacteriological samples were safe, the supply could be rejected. Now the U.S. Public Health Service is confronted with a situation which cannot be faced squarely. The only loophole is a statement of the Advisory Committee that judgment and discretion must be exercised in applying the standard. But this is unsatisfactory. If a city is conducting a reasonable program of cross-connection control, will the standard on "Sources and Protection" be winked at? If so, will not laxity result? Will not the sights be lowered when cities find out they really do not have to do anything? The operator is left entirely in the dark as to what minimum requirements will be enforced on a national scale. Until a determination is made concerning how big the stretch will be, little can be done.

Bacterial Standards

The bacterial standard is unsatisfactory because it substitutes the coliform index for the *Esch. coli* index and because it recommends two procedures not recognized by *Standard Methods.*[5] The bacterial part of the standard, as well as *Standard Methods* procedure, needs to be revised to permit use of other presumptive media than lactose broth, at least for Southwestern surface water supplies.

Until December 3, 1942, the *Esch. coli* index was the official criterion of contamination, because the former standard, adopted in 1925, was based on the 1923 edition of *Standard Methods,* which allowed differentiation of typical and atypical colonies. The U.S. Public Health Service Standard was not amended in 1936, when the last edition of *Standard Methods* was issued. At that time, however, many operators, responsible for water supplies which met the coliform index limits, voluntarily adopted the more rigid standard. Now it will be com-

[5] *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (8th ed., 1936).

pulsory that all waters meet the coliform index limits. This is objectionable to operators in the West and Southwest, where supplies are relatively clean surface supplies free of direct sewage pollution, but subject to pollution from the following sources:

1. Rain-water runoff for a few days in one or two of the winter months, the remaining months of the year being void of rainfall or runoff
2. Dust and wind-blown pollution
3. Water birds, when not controlled by shooting
4. Normal water bacteria in cyclic biological reservoir activity, at times including heavy algal growths
5. Crayfish, snails and other low forms of animal life.

All of these natural causes have at times been found to be responsible for false presumptive tests and atypical colonies from lactose broth enrichment. In Los Angeles the coliform index has been proved to be high in late summer, many months after significant fecal pollution could have been washed into the reservoirs and, therefore, is without alarming sanitary significance.[6] Obviously, it would be desirable to use an index organism more directly related to the type of pollution which means danger.

Los Angeles waters have always used and met the *Esch. coli* index standard. Never has a case of waterborne typhoid been traced to the water supply. The typhoid rate is less than 1 per 100,000 and this rate reflects imported typhoid from all causes in the entire County, the County Hospital being located within city limits. In 1939, a slight incidence of typhoid was noted by health authorities, but this was declared by the court to have been definitely not caused by water.

During certain months of the year, the Los Angeles supply will not meet the coliform index limits. With a supply having a perfect history so far as typhoid is concerned, it does not appear reasonable to force compliance with the new standard, in view of the failure of the U.S. Public Health Service to submit data indicating necessity.

Use of the coliform index is really no longer tenable since the Supreme Court of Illinois has ruled that the coliform group is too broad to infer that its presence can be considered evidence that typhoid might be present.[7] Many operators desire to have a sounder bacteriological record for use in cases where typhoid fever is alleged to have been contracted from the water supply. From this standpoint, the bacterial standard should be based on the *Esch. coli* index and, after proper procedures have been developed, the allowable indices might be made even more severe.

The new U.S. Public Health Service standard refers to two procedures not stated in *Standard Methods:* (1) substitution of a partially confirmed test employing brilliant green liquid confirmatory media for a 48-hr. incubation period, in place of the standard completed test; and (2) an alternate plan of stopping at the partially confirmed test if one of the four liquid confirmatory media recommended by *Standard Methods* is used with 48-hr. incubation. The medium used is presumed to be that which produces results nearest to the completed test. The former procedure involves costly media for large laboratories and the second method

[6] Goudey, R. F. Developments in Water Bacteriology. Jour. A.W.W.A., **30**: 2010 (1938).

[7] *People* v. *Bowen.* North East Reporter 2nd Series 33 Ill.; No. 25947 Sup. Ct. of Ill. (Apr. 15, 1941).

allows for a wide range of mathematical results. It does indicate the need of revising *Standard Methods,* so that the U.S. Public Health Service can base its recommendations on the standard procedures. This is all the more important since all certifiable waters must now meet the bacteriological standard.

Difficulties With Lactose Broth: Older bacteriologists remember when dextrose broth was used in place of lactose broth. It was criticized because it was fermented by too many organisms void of sanitary significance. The change to lactose broth satisfied operators in the north and northeast sections of the country, where the water supplies are relatively cold and, if polluted, are usually rather heavily contaminated. In the Southwest, where surface waters are 30°–40°F. warmer than eastern waters and pollution is less apt to be so severe, lactose broth becomes as offensive to operators as dextrose was in the older days. Los Angeles waters produce very heavy presumptive lactose broth counts, particularly in the 48-hr. period. The percentage of presumptive positive samples averages over 50 per cent during the year and over a six-year period has varied from a monthly average of 32 to 82 per cent of the samples.

One three-year study, results of which are shown in Table 1, was made on four raw water reservoirs which require chlorination part of the time. Arranged according to increased sanitary significance, these results indicate clearly the labor involved in trying to isolate relatively few of either the coliform or *Esch. coli* organisms.

This study indicates that, in the best raw water, the non-coliform organisms were twice as great as the coliform organisms and the *Esch. coli* content was less than one-half that of the coliform organisms. In the raw waters with higher *Esch. coli* content, but still in the class of good waters, requiring only chlorination, the non-coliform organisms were higher than the *Esch. coli.* It is noted that, regardless of the presence of either *Esch. coli* or organisms, there is fairly uniform frequency of non-coliform organisms. The use of lactose broth, taken as a whole, produced as many coliform organisms as it did non-coliform organisms and therefore cannot be considered specific for coliform organisms, causing an un-

TABLE 1

Lactose Broth Presumptives, Non-coliform and Coliform Organisms and Esch. coli *in Raw Water*

Reservoir	Total Samples	Percentage Total Samples Pos. in Lactose Broth	Results of Completed Test in Percentage of Total Samples		
			Non-coliform Organisms	Coliform Organisms	*Esch. coli*
Stone Canyon	1046	40.8	27.1	13.7	5.7
Hollywood	1028	59.3	39.9	19.4	8.4
Lower San Fernando	1829	80.8	35.1	45.7	24.6
Upper San Fernando	934	82.8	30.1	52.7	29.2
Total	4837				
Ratio Min. to Max.		1 : 2	1 : 1.5	1 : 3.9	1 : 5.1

reasonable amount of labor to separate the two.

Another study of distribution samples, Table 2, using the coliform procedure with the completed lactose broth test indicates how laborious it is to obtain a few positive coliform organisms from lactose broth. From this table it may be observed that:

TABLE 2

Lactose Broth Presumptives and Coliform Organisms in Distribution System Samples

No. of Samples	4234
No. presumptive positive:	
24-hr. test	366
48-hr. test	2021
Total	2387
No. proving to be coliform organisms:	
24-hr. test	195
48-hr. test	102
Total	297

1. Over 56.5 per cent of the samples were presumptive positive and over 84.7 per cent of these were 48-hr. gas formers, which, according to *Standard Methods,* constitute a "doubtful" test.

2. Nearly half the samples (49.4 per cent) proved to contain non-coliform organisms.

3. Of the 24-hr. positive presumptive tests, a little over 50 per cent indicated coliform organisms, whereas, of the 48-hr. positive presumptive tests, only 5 per cent indicated coliform organisms.

4. Over a third of the total coliform organisms came from the "doubtful" 48-hr. presumptive tests.

To eliminate the interference of non-coliform organisms and to reduce the 48-hr. incidence, crystal violet broth and lactose broth samples were run on the four raw water reservoirs. Lactose broth was used from April 194 through March 1942 and crystal violet from April 1942 through March 1943. While the samples were not run in parallel, the results are highly illuminating (*see* Table 3).

It is noted that lactose broth presumptive results show an apparently heavier pollution than the crystal violet results, yet the latter medium produced more coliform organisms. This is because the coliform organisms have a better chance to survive the enrichment period and crystal violet is more productive than lactose broth in such waters. It is noted that the crystal violet reduced the non-coliform organisms to an almost negligible quantity.

Los Angeles Bacteriological Procedures: Three independent bacteriological procedures have been adopted for Los Angeles waters. The first pro

TABLE 3

Comparison of Lactose and Crystal Violet Broths for Presumptive Tests

Source	Total Samples		Percentage Presumptives		Percentage Non-coliform Organisms		Percentage Coliform Organisms	
	Lactose Broth	Crystal Violet	Lactose Broth	Crystal Violet	Lactose Broth	Crystal Violet	Lactose Broth	Crystal Violet
Stone Canyon	251	245	75.3	13.9	64.9	0.8	10.4	13.1
Hollywood	304	298	76.0	39.0	57.2	0.3	18.8	38.7
Lower San Fernando	515	596	81.3	38.6	48.3	1.8	33.0	36.8
Upper San Fernando	272	245	90.6	38.2	57.6	3.3	33.0	35.9

cedure is that recommended by the U.S. Public Health Service for its required number of samples for waters to be furnished to interstate carriers. These samples are run according to the completed test routine of *Standard Methods*. Little attention is given to these results in the operation of the water system but, technically, in every respect, they provide the data called for by the standard. The second procedure involves the collection of seven times as many samples for primary inoculation into crystal violet broth, followed by two procedures, including the completed test and differentiation to *Esch. coli*, employing lactose broth at 45°C. and the Voges-Proskauer test. These results conservatively indicate significant contamination and are invaluable in the bacteriological control of the water supply. The third procedure is the examination, three times weekly, of samples below six large chlorination plants with five 100-ml. portions, using the above-mentioned crystal violet procedure. This last test is conducted for the purpose of determining how much increase in work is involved and the degree of mathematical accuracy obtained with the larger sample. To date, 574 parallel samples, of five 100-ml. portions and five 10-ml. portions each, have been examined. Results are summarized in Table 4.

In the case of the five 100-ml. portions, 20 per cent of samples may have all tubes positive, indicating that the samples were 19 times better than the standard. The five 10-ml. portions were correspondingly 29 times better than the standard, which does indicate a slight advantage for the larger portions; but both were so far on the safe side that this difference seemed not to be worth the additional trouble. One more positive sample in the five 10-ml. samples would still have given a result 14 times better than the standard. In the matter of the number of total portions positive, the five 100-ml. samples were 21 times better than the standard and the samples with the five 10-ml. portions were 18 times better, indicating little difference in the two procedures.

TABLE 4

Comparison of Use of Five 100-ml. and Five 10-ml. Portions of Treatment Plant Samples

Size of Samples	No. of Samples	All tubes positive (for 100-ml. portions) 3 or more tubes positive (for 10-ml. portions)		No. of Portions	Standard Portions Positive	
		No.	Percentage		No.	Percentage
100 ml.	574	6	1.05	2870	82	2.86
10 ml.	574	1	0.17	2870	16	0.56

From the practical standpoint, it is more difficult to tell how good samples might be during the testing period when the larger portions are used. When all 10-ml. portions are negative in 48 hr. in lactose broth, the water is known to be safe and the tests terminate. In the case of the larger portions, an equal water may cause presumptive tests which require a week to prove equivalent safety.

The objections of larger sample bottles, increased laboratory personnel, larger incubator space and the cumbersome procedure do not warrant its use in the case of Los Angeles water.

It is gratifying to note the real progress being made by various bacteriologists in their effort to develop a practical procedure for the rapid detection of fecal contamination in water. Perhaps the most promising line of re-

search in this connection is that involving studies in high temperature 44°–46°C.) incubation. The satisfactory results reported by Wilson in England,[8] Ferramola and Monteverde in Argentina [9] and Perry and Hajna in this country,[10] to mention but a few of the many workers who have followed the original work of Eijkman [11] in this field, seem to justify further investigation to determine the full possibilities of this method in water bacteriology.

Cost of Laboratory Media: Lactose broth materials, for 100 liters of double strength concentration, cost $19.72 as compared with $67.04 for one of the most promising media for presumptive tests. Where 30,000 samples are analyzed annually, the added cost of the better material exceeds $400 per year. Although the better material involves far less labor and eliminates considerable confirmation material, many laboratories could not reduce personnel anyway, so that the net cost would average $350 in addition to present costs. Any future procedure should therefore give some weight to cost of materials for the tests.

Sampling provisions: The new requirements in the bacteriological standards regarding sample collection, including provisions for number of samples and time of sampling and resampling, are sound. All persons involved realize that basing the number of samples on population in the supplying zone is a rough approximation that does not take into account the volume of water taken by carriers or the effectiveness of treatment in relation to its load.

It should be particularly noted that only distribution system samples are required so far as the application of the standard is concerned. In general the operators in smaller cities will have to increase the number of samples taken, whereas, in the larger cities, the number of samples will be far less. The number of samples taken in Los Angeles to conform with the new standard represents a decrease of 87.5 per cent in comparison with previous methods.

Physical and Chemical Standards

The standards applying to physical properties have not been changed. The standards applying to chemical limits were unsatisfactory from the start. The new standards are far more acceptable but can be improved. The new standards prohibit any addition of hexavalent chromium, heavy metal glucosides or any substance known to produce deleterious physiological effects. This means that a number of slime control and corrosion control chemicals must not be used in cold- or hot-water domestic piping or in systems connected with domestic piping systems which are not protected against backflow by an air gap method.

The chemical standards single out limits for lead, fluoride, arsenic and selenium, which are unusual constituents in most waters. Los Angeles water occasionally reaches 0.01 ppm lead, averages 0.6 ppm. fluorides, has an average arsenic content of 0.025 pmm. and is void of selenium.

[8] WILSON, G. S. *Bacteriological Grading of Milk.* Longsmans Green, London (1935).

[9] FERRAMOLA, R. & MONTEVERDE, J. J. Incubation at 44°C. as a Means of Detecting *Esch. coli.* Bol. Obras Sanit. Nacion (Argentina), **2**: 265 (1938).

[10] HAJNA, A. A. & PERRY, C. A. A Comparative Study of Presumptive and Confirmative Media for Bacteria of the Coliform Group and for Fecal Streptococci. Am. J. Pub. Health, **33**: 550 (1943).

[11] EIJKMAN, C. Centr. Bakt., II Abt. (Ger.), **37**: 742 (1904).

Arsenic tests were first started routinely on June 17, 1941, prior to the declaration of war. The first results indicated 0.05 ppm. arsenic in the distribution system for several months duration, while certain raw waters in Owens Valley exceeded 1 ppm. This high content has been declining steadily. The high arsenic incidence represented the addition of some two tons of arsenic and could not have been due to sabotage. It does coincide with a period of earthquake, geyser and hot spring activity in the Hot Creek area of Owens Valley. For several months many people along the Los Angeles aqueduct used water containing between 0.05 and 1 ppm. arsenic without noticeable effect.

It is believed that the limits given for the above-mentioned poisons are satisfactory where the same water is used continuously by the same individuals. Much higher limits may be tolerated for peaks of short duration or for use on interstate carriers, where the use of water is only incidental.

Under Sec. 4.22 of the chemical standard is given a list of elements and desirable limits which should not be exceeded even for short peaks or for incidental use because excesses would result in physiological disturbances that would involve inconvenience, although not death. A much higher limit could be set for chlorides, provided magnesium were below 100 ppm.

Recommendations

From the operator's viewpoint, the U.S. Public Health Service, the American Water Works Association and water works operators each have opportunities to be of greater service toward the practical solution of water supply safety:

U.S. Public Health Service: The standard should be amended:

1. To state the basis on which provisional certificates are issued
2. To state in what matters judgment shall be exercised, with a clear statement as to types and degrees of sanitary defects which will not be tolerated and methods of dealing with them
3. To eliminate references to 100-ml. portions, since they were designed for treatment plant control and not for distribution system samples
4. To eliminate brilliant green bile lactose broth as a final confirmation test, partly because of its excessive cost and partly because it is not yet recognized by *Standard Methods*
5. To state that, as amended editions of *Standard Methods* appear, they will be immediately considered for adoption by the U.S. Public Health Service
6. To permit higher limits for arsenic and possibly other constituents for shorter periods.

It is hoped that the U.S. Public Health Service can formulate some plan so that operators can be given lists of carriers on their system and be notified when each is given certification.

American Water Works Association: There are some real jobs pending for the American Water Works Association so far as drinking water standards are concerned. A water safety committee should be appointed to formulate: (1) what constitutes safe and allowable uses of water as contrasted with non-permitted uses; (2) procedures which will minimize the forces of back-flow; (3) specifications for safe back-flow devices, which can also be harmonized with National Board of

Fire Underwriters' requirements; and (4) machinery whereby protective devices may be tested and approved.

The Joint Editorial Committee on *Standard Methods* should abandon the coliform index as a criterion of pollution and not only substitute the *Esch. coli* index, but recommend a procedure, after due investigation, which will eliminate lactose broth as a presumptive test medium and which will be, economically, within the reach of large laboratories.

Water Works Operators: It will not be until the matters above outlined have been crystallized that the present ideal standards will be made practical so that the operator will know just what will be done uniformly over the entire country. In the meantime, those improvements which are obviously needed should be made.

From the Operator's Viewpoint—C. K. Calvert

The new U.S. Public Health Service Drinking Water Standards repeat the statement: "These standards are adopted for use in the administration of the Interstate Quarantine Regulations as they relate to the drinking and culinary water supplied by common carriers in interstate commerce."

Nothing was said about water supplied to municipalties, regardless of size, in any of the standards previously promulgated. In this latest standard, however, the number of samples examined per month is specified on the basis of population served. At the same time no mention is made of the number of people served by the common carrier engaged in interstate traffic. Although it was anticipated by water works men that the original (1914) standard would be applied to all water supplies, whether or not they served interstate carriers, this was not formally done. It was not until the current standard was issued, however, that the provisions were directed at the municipality in which the water supply was located, a fact which has been the source of considerable amusement among water works men.

The quality of water furnished by municipalities and private companies in the United States has improved very materially since the promulgation of the field federal standard in 1914. This improvement, however, has not been exclusively the result of the issuance of the standards. Of the many valuable contributions to the progress of the first in the intervening 30 years the majority have been the work of water works men themselves. This is pointed out not to discredit the work of public health workers, but to emphasize the fact that water works men themselves are anxious to furnish the best water possible. Perhaps this will explain why the present standard will be applied to all water supplies, just as have previous standards, regardless of any limiting statements by the advisory committee or by the U.S. Public Health Service.

Bacteriological Requirements

The principal requirement of the standard is that the water meet certain limits of coliform density. Two alternative procedures for this determination are provided—based on the use of 10-ml. portions and the use of 100-ml. portions. If water supply officials choose to use the 10-ml. portions, they may furnish a water in which 10 per cent of the 10-ml. portions examined contain coliform organisms. Thus, a

limit of 10 coliform organisms per liter is established. If, on the other hand, they elect to plant 100-ml. portions, the water they supply may contain only 6 coliform organisms per liter.

Anyone who has done laboratory work or who is familiar with the results obtained in laboratory analysis will know that the difference between 10 and 6 coliform organisms per liter is unimportant. It is unimportant not only from a hygienic standpoint, but because it is not possible to treat a contaminated raw water so that it will fall within one or the other of these limitations. Using modern chlorination methods, it is more than easy to meet either of the limiting densities permitted.

It is not at all clear, however, that the initial incubation of 100-ml. portions in *standard lactose broth* will result in the detection of more coliform organisms than if 10-ml. portions were used. For instance, in the past nine years, approximately 20,000 each of 100-ml. and 10-ml. portions of a plant effluent have been enriched in standard lactose broth with confusing results. The 100-ml. portions yielded coliform organisms at the rate of 2.6 per 100 liters of sample and the 10-ml. portions at a rate of 6.2 per 100 liters, or 2.33 times as great as with the larger volume. The reason for such discrepancy in the figures obtained by the examination of different quantities is not at all clear. It is suggested that it may be due to overgrowth in the incubation of the larger portions.

At this time, materials of all sorts, even such items as are not considered critical, are difficult to obtain because of labor shortages. Thus, it appears to be a very unwise and unpropitious time to promulgate standards which will require the use of new equipment and apparatus and larger volumes of culture media and incubator and laboratory space. Similarly, labor shortages in local water works make it impossible for many supplies to take on the added burden of using 100-ml. portions. These facts are especially pertinent when it is realized that no discernible good will be effected by the change, so far as public health is concerned.

The culture medium to be used in examining water to determine whether or not it meets the new standard is that specified in *Standard Methods,* placing part of the problem right back in the laps of water works men. It should be pointed out here that the character of the enriching medium can be improved if the results obtained in the use of tryptose lauryl sulfate lactose broth are recognized. The use of this broth prevents the growth of certain bacteria of no sanitary significance and allows those which conform to the coliform group to grow more unobstructedly. By the use of this broth in enrichment, more coliform organisms will be obtained and the overgrowth problem will be met. Thus, it is possible that the discrepancy between results obtained in using 100- and 10-ml. portions may thereby be eliminated.

Sampling Requirement

One of the good points in the new standard is its specification that samples be taken from the distribution system, since it is the delivered water that is important and not the water that leaves the purification plant.

A distribution system residual chlorine of such intensity that the water can still be used for drinking will protect against very mild contamination

from back-siphonage or cross-connections. Any important source of contamination, however, could not be controlled by any reasonable amount of residual chlorine. Although the literature is full of examples showing that active (not chloramine) chlorine can be maintained throughout a distribution system, a great many water works men know from experience that it cannot be done universally. It would be a great deal more satisfactory to protect the distribution system from contamination by requirement of the use of inspected back-flow protection devices than to require that the water in the distribution system contain a specified amount of residual chlorine, even though every operator would be happy to be able to deliver a moderate residual to all customers, regardless of their location on dead ends.

The "Manual of Recommended Water Sanitation Practice" accompanying the standards specifies that the "test for residual chlorine should be made in accordance with the eighth edition of *Standard Methods for the Examination of Water and Sewage,* 1936. . . ." It seems that it might have been better to have specified "the latest edition," instead of naming the eighth edition, so that later editions, if they issue before further revision of the standard, would automatically govern.

Other Requirements

Perhaps it is well to establish as high ideals as possible whether or not they can be attained. The provision that "raw water should be free of excessive amounts of acid, microscopic organisms or organic matters causing any interference with the normal operation and efficiency of water treatment processes" is one which every plant operator would like to realize. The only disadvantage to the operator would be that, under such ideal conditions, his own work would be very much less important, in that less expert supervision would be needed.

The manual accompanying the standards recommends that slow sand filter sand depths range from 36 to 40 in. and that no filter be operated with less than 20 in. of sand. Further it recommends an effective size of 0.25–0.35 mm. and a filtration rate of about 2.5 mgad. (million gallons per acre per day). In this connection the writer wishes to cite the example of one filter plant, of which he has knowledge, which has operated for many years with less than 20 in. of sand of an effective size of 0.45 mm. This plant has operated at rates up to 7.5 mgad. and has produced water that has been entirely satisfactory from the standpoint of turbidity, taste and odor and, with pre-chlorination and post-chlorination, from a bacteriological standpoint.

Résumé by A.W.W.A. Representative—C. R. Cox

THE technical provisions of the revised Drinking Water Standards have been discussed from several viewpoints in the preceding pages. This résumé, therefore, will deal primarily with administrative factors of interest to the water works field. Before discussing the detailed provisions of the standards, however, it seems desirable to emphasize several important features:

1. Officially the standards apply only to water supplies serving interstate carriers, but actually they will be ac-

cepted as a general guide for all public water supplies.

2. The standards should be administered in the light of the administrative policy outlined quite clearly in the introductory material, which specifically emphasizes the difficulty of preparing quantitative standards for many intangible features of public water supply systems and, therefore, permits the exercise of administrative judgment.

3. It is very important to distinguish between the respective fields of the "Certifying Authority," i.e., the U.S. Public Health Service, the "Reporting Authority," i.e., the respective state departments of health, and the owners of a specific water supply serving a common carrier.

4. The distinction between the official standards (which are quite brief) and the "Manual of Recommended Water Sanitation Practice" must be borne in mind constantly.

Sources of Water Supply

The official standards contain only a few brief and general sentences pertaining to sources of water supply. Part I of the manual, however, contains a list of important factors pertaining to sources to be reviewed by the "Reporting Agency" in its appraisal of a given water supply. In general, it appears that the water works profession will agree with the significance accorded various factors concerning sources of supply.

Water Treatment Plants

The official standards contain no specific provisions concerning water treatment plants, inasmuch as they deal primarily with the quality of the water actually delivered to the common carrier. The procedures used in providing water of acceptable quality, therefore, are not specified in the standards but are covered in the manual.

Part II of the manual presents "Recommended Sanitary Requirements for Water Treatment Systems." The suggestions regarding degree of treatment for raw waters of specified quality deserve special attention. These suggestions are based upon extensive and continuing research by the U.S. Public Health Service. It would seem that the experimental data should be supplemented by the collection of widespread statistical records at existing treatment plants having local laboratory facilities. In this way, it would be possible to show the actual effectiveness of treatment by records over considerable periods of time for waters and plants of widely differing characteristics. It is especially important that extensive statistical records be accumulated locally concerning the effectiveness of treatment by chlorination alone, in the light of improved chlorination practices and control procedures. Available information seems to indicate that modern chlorination is much more reliable than implied by the suggestions of the manual, in that the number of surviving bacteria in chlorinated water is not proportional to the number in the raw water except when borderline conditions prevail. Such conditions are, of course, as unsatisfactory as poorer results and so should not be used in appraising the effectiveness of chlorination. In fact, the development of super-chlorination and knowledge concerning the state of activity of residual chlorine is ushering in a new era in chlorination practice. These developments are of paramount economic importance as they provide greater flexibility in the degree of treatment of polluted raw waters.

The suggestion that the available capacity of treatment plants be at least 50 per cent above the average daily draft cannot be met at many existing plants, but this suggested guide becomes more practical when interpreted in the light of the suggested maximum rate of filtration of 3 gpm. per sq.ft. of filter area for rapid sand filters, because most existing plants have a designed rate of 2 gpm. per sq.ft., which can be increased insofar as hydraulic limitations permit. The important point, of course, is that a filtration plant be so designed that unforeseen, but reasonable, increases in consumption can be met without deleterious influence on the quality of the final effluent. It is evident that many treatment plants should be appraised to determine just what the maximum safe capacity is and that trial runs should be undertaken to disclose "bottlenecks" which may limit capacity to a serious degree or which may prevent effective treatment of the water at high rates.

The manual contains detailed suggestions as to chlorination practice. Special attention is directed to the suggestion that the maximum capacity of chlorination equipment be 50 per cent greater than the highest anticipated dosage. This emphasizes the need for greater attention to marked fluctuations in the chlorine demands of many raw waters. The suggested reserve capacity most likely would be available if chlorination equipment were in duplicate, as advocated, provided each unit has a capacity somewhat greater than the known maximum demand. Many chlorinator installations are deficient in this regard.

It is believed that caution should be used in interpreting the suggestions embodied in paragraph B(10)(e)2 of Part II of the manual, because the concentration of residual chlorine required in the effective disinfection of any given water depends upon a number of variable factors which must be appraised in the light of specific local conditions. It is suggested in the manual that residual chlorine be maintained throughout distribution systems. This obviously is intended to provide a factor of safety and also to minimize the effect of unforeseen secondary pollution. The development of superchlorination practice has created a definite technique for the maintenance of appreciable concentrations of active residual chlorine throughout distribution systems, but more practical experience is needed with waters and systems of various types before superchlorination can be adopted with assurance without considerable experimentation. Obviously, this treatment cannot be initiated extensively during the war period because of scarcity of materials. The control of secondary pollution by this suggested procedure draws attention to the lack of any adequate procedure for the control of secondary pollution of untreated supplies, even though the chance of secondary pollution may be as great as with a treated supply.

The manual suggests that tests for residual chlorine be made in accordance with the eighth edition of *Standard Methods*. This is logical for official standards, but attention is directed to proposed changes in *Standard Methods,* now that improved practice has made the present published procedures antiquated.

Operation and Control

No one questions the ideal that all water treatment plants should be in charge of technically trained operators

Economic limitations, however, prevent the adoption of this suggestion of the manual in many cases, even though the operation of some small treatment plants may present more difficult problems than the operation of larger plants. There is very definite need, therefore, for the more extended use of the services of consulting chemists or sanitary engineers to supervise plants too small to be under full-time technical supervision. The discrepancy between the facilities actually available in many treatment plants and ideals of practice, therefore, should be the subject of further study by the Association, to disclose present deficiencies and economic limitations, to review state regulations relating to licensing or certification of operators critically and to prepare an administrative guide for operation and control of water treatment plants.

Distribution Systems

The only reference to distribution systems in the official standards is Sec. 1.4, which defines sanitary defects (including defects in distribution systems). Portions of Part II and all of Part III of the manual, however, deal specifically with the subject. It is pertinent to compare the suggestions given in these portions of the manual with the A.W.W.A. "Tentative Manual of Safe Practice in Water Distribution." [12]

The intent of these two manuals is the same—the protection of the quality of the water passing through distribution systems, equalizing reservoirs, booster pumping stations, etc. The A.W.W.A. manual, however, is much more comprehensive, especially in regard to design and construction. Both manuals are suggestive rather than mandatory standards.

[12] Jour. A.W.W.A., 34: 915 (1942).

The stress placed on cross-connections, inter-connections, back-flow connections, etc., in both manuals raises the administrative problem of determining just how far local water supply officials should go in inspecting private properties for dangerous cross-connections, inter-connections, etc.

Ordinarily, plumbing ordinances of municipalities are administered by local health departments rather than by water departments. Obviously, they would not be administered by private water companies. Furthermore, building inspection departments of municipal governments frequently deal with matters of this nature.

There seems to be some question of just how far water supply officials, especially those representing corporations, may go in supervising plumbing fixtures on private property served by the supplies under their jurisdiction. It is very definitely established, however, that water officials may refuse to serve a specific private property if, in their opinion, such service would menace the supply as a whole. A more detailed investigation of the administrative and legal problems involved in problems of this character should be made by a committee of the Association. In the meantime it seems evident that local water officials should not act independently on matters pertaining to cross-connections or interconnections on private property, but that they should encourage the enactment of suitable plumbing ordinances by the municipalities they serve, so that the needed administrative procedure controlling dangerous plumbing installations may be provided, to facilitate co-operation between local health department officials, building inspection departments and local water supply officials. Standards for "back-flow

preventers" are now in preparation by the American Standards Association. The A.W.W.A. is represented in this committee activity.

In Sec. B(7), Part II, of the U.S. P.H.S. Manual it is suggested that filtered water in storage reservoirs be located above the ground-water table. It is evident, of course, that ground water exposed to pollution by seepage from sewers should not be allowed to enter reservoir structures through leaks, but there seems to be no reason why such reservoirs should not be constructed below the surface of the ground and below the ground-water table at appropriate locations, especially if the suggestions on construction given in the more extensive text of the A.W. W.A. manual are followed.

The suggestion in paragraphs B(8)(b) and B(8)(d), Part II, of the U.S.P.H.S. manual that no conduit or basin containing treated water should have a common dividing wall with another conduit or basin holding raw water or water in a prior stage of treatment would apply to many portions of existing treatment plants. Obviously, special structural precautions should be taken to insure the tightness of such partition walls. There is some question, however, whether the suggestion should apply solely to walls separating raw and treated water or also to treated water and water in a prior stage of treatment. The phrase "prior stage of treatment" would distinguish between filtered water and filtered chlorinated water. While many water works officials may doubt the necessity of this restriction, they would support the need of providing means of preventing any pollution of treatment plant effluents by raw water.

The manual also suggests that mains should show no leakage under a pressure test. This ideal, however, is seldom met. Reference is made to Sec. 5.45 of the A.W.W.A. manual, which covers leakage tolerance as based upon Sec. 15 of A.W.W.A. "Standard Specifications for Laying Cast-Iron Pipe —7D.1–1938."

The provisions of Sec. B(7), Part III, of the U.S.P.H.S. manual suggest the exclusive use of copper or brass service pipe. This suggestion, of course, is intended to insure tightness of service piping, irrespective of the corrosiveness of water supplies in general. Suitability of service piping, however, is dependent upon specific local factors, including the corrosiveness of a specific supply. In the light of the successful use of iron service pipe in many sections of the country, reference is made to the more general provisions of the Sec. 5.5 of the A.W. W.A. Manual.

Physical and Chemical Characteristics

In the official standards provisions for chemical characteristics, a clear-cut distinction should be made between Secs. 4.21 and 4.22, because the former provides specific quantitative requirements and the latter, desirable upper limits.

Referring to Sec. 4.1, one may also question the required limits as to turbidity and color of 10 and 20 ppm., respectively, because a question of health is not involved. In effect, the limits imply that waters having turbidities or colors exceeding the values noted would have to be filtered. Modern practice supports the filtration of most surface waters, even those having turbidities and colors below the stated limits, but programs for the installation of filtration plants usually

are based upon many factors, including the physical character of a supply. The quantitative limitations of permissible concentrations of lead, arsenic, fluorine and selenium should present no serious problem to water works officials. The presence of lead in potable water is usually incidental to the corrosion of lead pipe, so that difficulties from this toxic material will normally be restricted to specific properties on which lead pipe is used to conduct corrosive water. The lead content of miscellaneous samples of water would, therefore, be of significance only for the properties on which the samples were collected. The presence of lead in such samples would, however, give a general indication of whether or not the supply should be treated or if lead pipe should be used in the community.

Arsenic occurs in nature, but is normally not significantly present in natural waters except incidental to the careless use of tree spray and animal "dips" on the watersheds of tributary streams. Proper control of the sanitation of the water supply should indicate where steps should be taken to prevent contamination with arsenic.

Fluorides are associated with natural deposits of fluor spar. There seems to be no accurate information as to the distribution of fluoride-bearing waters, although considerable work has been done in connection with the distribution of mottled enamel associated with high concentrations of fluorides. There is need, therefore, for nationwide study of this subject. Local water officials should determine the fluoride content of water supplies under their jurisdiction, so that a nationwide study may be facilitated.

Selenium is relatively rare and would not appear to present a problem except in water supplies in areas where deposits of selenium-bearing minerals occur. Here again there is need for a nationwide survey to determine the selenium content of the natural waters of the country.

The more general provision of the standards deals with the prevention of entrance, into potable water supplies, of barium, hexavalent chromium, heavy metal glucosides and other substances with deleterious physiological effects. Because of the nature of these substances they are not likely to be present in natural waters, except possibly in streams draining watersheds on which chromium plating plants are located. The implication, therefore, is that these deleterious substances should be excluded from potable water supplies through control of interconnections with boilers, air-conditioning systems, industrial equipment, etc.

The provisions of Sec. 4.22 of the standards as to certain other constituents in the water need not be discussed, except to point out that the suggested limitations for total alkalinity, phenolphthalein alkalinity and pH are intended to indicate the points beyond which overtreatment with alkalies would be objectionable, rather than to imply that treated waters meeting these limits would be in mineral equilibrium. The language of the standards in this connection might well be clarified in their next revision.

Bacteriological Quality

Briefly, the revised standards of bacteriological quality continue the same quantitative values as the 1925 Standard, but now specify that the samples used in appraising bacteriological quality be collected solely from the distribution system, that samples be de-chlorinated within 20 min. after

collection, that the supplies be appraised in the light of series of samples collected in each calendar month and that the frequency of sampling supplies be based upon the population served.

In general, the requirement of monthly appraisal of statistics on bacteriological quality represents a more rigid standard than that of annual appraisal. This should be realized by water works officials and appropriate steps should be taken to prevent any seasonal deteriation in water quality. Local water supply officials should have no difficulty in developing monthly records. It is evident, however, that close relationship must be maintained between the local and state officials to facilitate appropriate monthly review of the records by the "Reporting Agency."

The required frequency of sampling is probably the most controversial feature of the revised standards, notwithstanding the acknowledged fact that there is rather universal need for more frequent examination of samples of water collected from the distribution systems of local water supplies. Obviously, the population served has no direct bearing upon the technical requirements of frequency of sampling, but, for economical reasons, it was found judicious to base the frequency upon the ability to afford local laboratory control, which ability is indicated generally by the population served. The population also is an approximate measure of the public health importance of any given supply.

It is rather evident, however, that the specified frequency of sampling implies local laboratory control. The most serious problem is in connection with communities with populations of less than 10,000, because most communities over this population should be able to maintain local laboratory control. Obviously, then, the officials in charge of water supplies of moderate size are confronted with the definite need of providing local laboratory control. While essential laboratory equipment can be purchased during the war period, it is doubtful whether many new laboratories can be installed until after the war. Therefore, plans should be prepared for the initiation of laboratory control at that time. In general this need is a basic shortcoming facing water works officials today.

The requirement that samples be collected from distribution systems rather than from the effluent of treatment plants, is obviously justified, because the quality of the water as delivered to the consumer is the important factor. The secondary pollution of water passing through water distribution systems, however, is a distinct problem, especially where open reservoirs or other structural details permit the entrance of dust, etc., into the water. The interpretation of the significance of coliform organisms from such sources is complicated by the doubt created by the unknown, but possible existence of cross-connections or interconnections which may be contributing secondary pollution. There is a distinct need, therefore, for an exhaustive study of the biology and bacteriology of distribution systems to provide more definite information for the control of secondary pollution and to serve as a guide in the interpretation of the significance of coliform organisms in the samples collected. At the present time these unsolved problems have the net effect of increasing the severity of the standards, and, thus, of increasing the magnitude of the problems of meeting their requirements.

It is evident, therefore, that the revised Drinking Water Standards impose definite technical and administrative duties upon those operating water supply systems serving interstate carriers. The suggestions as to water works practice contained in the manual should be interpreted as recommendations rather than requirements. The scope of the official standards and of the manual clearly emphasizes that water quality cannot be denoted by a single simple numerical index as to the content of coliform organisms, so sound technical judgment must be used in evaluating the somewhat intangible factors not capable of quantitative expression.

Résumé by U.S.P.H.S. Representative—J. K. Hoskins

IT might be helpful for a clearer understanding of the development of the present revision of the Public Health Service Drinking Water Standards to review briefly the procedure by which these revisions were brought about. The Surgeon General requested each national organization interested in the subject to designate a representative as a member of an advisory committee for the purpose of considering revision of the "Treasury Department Drinking Water Standards" in force. Each of the national organizations interested named its representative and, accordingly, the committee was appointed by the Surgeon General in February 1941. To this group, a few additional members-at-large were added, to balance the geographical distribution of the committee and, to aid the committee in the development and formulation of revisions, the Surgeon General also appointed a technical subcommittee composed of officers of the Public Health Service.

After exhaustive review of all phases of the subject, the advisory committee made its recommendations to the Surgeon General for certain revised drinking water standards which were adopted on September 25, 1942. It must be presumed, therefore, that during this interval of almost two years the members of the advisory committee had ample opportunity and did discuss with the national organizations which they represented the subject matter of the revisions and their import and that all of these organizations had ample time and opportunity to express, through their designated representatives, their desires concerning the requirements of the proposed revisions to these standards. The revisions finally adopted, therefore, must be considered to carry the broad approval of the national organizations interested in the safety of public drinking water supplies as they pertain, not only to interstate carriers, but to all of the civilian population of the country as well.

In this method of development of such a document, all shades of interest and viewpoint are presented for consideration and compromises of the individual views of various members of the committee are necessary to arrive at a definite conclusion. Such concessions were in fact made by various members of the advisory committee. On the whole, however, it is believed that these revisions represent, as nearly as it is possible to do so, the best technical judgment of the members of the committee and of the professional societies which they represent.

The current edition of the Drinking Water Standards is not intended to be a static document, but must be consid-

ered as available for revision and modification as progress in the field of water works treatment advances. If later it is determined that the present revisions are not in harmony with the then current standard practice or are demonstrated to be otherwise impracticable, there should be, and is, no impediment to such modifications as will make them both practical and effective. The committee agreed that it was essential to follow the now current universally accepted methods of water examination and treatment. Therefore, the current edition of *Standard Methods,* as recommended by the American Public Health Association and the American Water Works Association have been specified in the current revision. Those who take issue with these analytical procedures should argue their case with the committees responsible for these methods.

It has been indicated that the standards are impossible of attainment by all small water works of the country and are therefore unreasonable and unjustified. The advisory committee recognized that it was faced with one of two alternatives: (1) to develop a standard that represented an ideal practicable of attainment and which all properly designed and constructed plants could meet if due diligence and continuous operation care were exercised; or (2) to write a standard which all plants, whether properly constructed and operated or not, could meet without additional care or concern. Obviously the latter course would be unwise to follow, so it was agreed that a standard should be developed that is practical of attainment and, which, for its complete observance, would require structural and operational facilities of a high order of merit. In other words, it was considered that a standard should be developed that is possible of attainment and that will, if observed, insure a reasonably safe water supply but which will also require, in some instances, material improvements in plant construction and operation. This objective is in fact a continuation of that of the previously developed Drinking Water Standards.

Discussing briefly some of the points made by the previous discussors, the writer finds that there is evidently no agreement in views concerning what are considered to be undesirable features of the present revised standards, a number of the points mentioned by some discussors having been contradicted by others. There are, however, some features of the present standards which will bear further discussion. One such point frequently made is that the requirements are such that central laboratories would experience great difficulty in examining the numbers of samples required under the present revision. This brings to the fore the question of whether many states are not now exercising too highly centralized laboratory control operations. Decentralization of such laboratory activities might be definitely indicated. The time consumed in shipment of water samples over long distances in many cases makes impossible worth-while interpretations of the laboratory results obtained by such practices. The ultimate value of results from un-iced samples 24 hr. or more in transit is certainly questionable.

Another point of objection is that the number of samples to be examined from the distribution system is excessive. The sanitary engineer or health officer, as well as the consuming public, is interested primarily in the water delivered to the ultimate consumer. The treatment process, while obviously

requiring careful laboratory supervision, does not necessarily represent the quality of the product as it reaches the consumer's tap. Therefore the committee considered it highly desirable that the quality of any water supply must be ultimately gaged by the quality of the water furnished to the consumer and that this quality should be determined throughout the distribution system at sufficiently frequent intervals to insure that a safe product is being supplied. Following this line of reasoning, it is obviously essential that samples be de-chlorinated at the time they are taken and that the residual chlorine which may be in the sample as drawn from the tap be neutralized at the time of collection, rather than to be allowed to continue its disinfecting action during the time the sample is in transit for laboratory examination.

Another point brought out is that, although these standards may be desirable for use on interstate carriers, they are not necessarily the best that can be evolved for the regular users of public drinking water supplies and that the entire public water supply industry should not be required to abide by requirements devised for a relatively small group of consumers. The Public Health Service has no jurisdiction or desire to require such universal acceptance. It is believed, however, that the water-consuming public has sufficient concern and interest in the matter to demand that the drinking water supplied for their general use conform to some reasonable standard of quality and that it is willing to pay for such a product. Consumers have found that the federal standards have been reasonably satisfactory and are not impossible of wide attainment, and know that, where common sense in the interpretation of the standards is exercised, a safe drinking water supply is assured. It is fair to say, at least, that the water supply profession, as well as the public it serves, would be definitely adverse to a lowering of these standards and that all have just cause to be proud of the high quality of the public drinking water supplies of this country.

Summation of Issues Raised in Discussion

With the publication of this extended record of the discussion of the "1942 Drinking Water Standard," as it developed at the Cleveland Conference, the Editor of this Journal hopes to bring to a state of suspension the necessity of devoting space in the Journal to "previews" of the effects of the Standard.

There appear to be at least two issues of substantial importance which can be, at a later date, made the basis for filing of evidence rather than assumptions.

One of these relates to the administrative problem derived from the sampling frequency requirement. A year or so after the war has ended it should be possible to develop a record of the volume of work required from the reporting agencies by the certifying authority prior to its acceptance of a water supply for use on common carriers.

The other issue relates to the diagnostic value of 100-ml. plantings. What evidence will be disclosed by the coliform densities shown over and above that shown by 10-ml. plantings? It has been shown that the computation based upon 100-ml. positive findings is more refined mathematically

than one based upon 10-ml. positives. But it has not yet been broadly shown that 100-ml. positive coliform findings tend to develop at a pollution level different from that which 10-ml. positives appear. In fact, several workers suspect that further study of the media used needs to be made before 100-ml. plantings justify the labor involved. Here there is a definite need for an answer to the question—what is the record of X water systems in the matter of 10-ml. and 100-ml. positive results? What interpretations of system efficiency are made possible by the 100-ml. plantings which were not possible with 10-ml. plantings?

These standards, as well as their predecessor 1914 and 1915 documents, "are adopted for use in the administration of the Interstate Quarantine Regulations as they relate to the drinking and culinary water supplied by common carriers in interstate commerce." By the omission of a precise statement in the Surgeon General's letter of adoption or promulgation, the standards are not claimed to apply to water *not* used on common carriers in interstate commerce. But much of the discussion has appeared to assume such an intention. The implications of such an attitude need to be considered with professional care and with full recognition of the governmental and administrative policies deriving therefrom.

The "Manual of Recommended Water Sanitation Practice," prepared as a guide to reporting agencies, is not a part of the standards. But it tends to go rather deeply into design as well as operating criteria for water treatment and distribution systems. It is, in part, sharply in disaccord with the report of the A.W.W.A. Committee on Distribution System Safety. At points, it stipulates design or operating details more theoretical than realistic. This document deserves far more study and analytical comment that it has yet received. When wartime demands lessen, the A.W.W.A. must reactivate its Committee on Distribution System Safety and develop a considered appraisal of the Manual to the end that (1) its defensible requirements be accepted by water works men and (2) its indefensible requirements be sharply challenged. Only by such action will real progress be made in water supply sanitation.—Harry E. Jordan, *Secretary*.

Women Filter Plant Operators

By Robert L. Stewart

THE filter plant operations which are described herein, relate to the military area adjacent to the Maryland coast. The water property is under War Department control and the employees are civil service personnel.

Water is supplied at this time, from two modern filter plants, one treating surface water with a design capacity of 4 mgd., and the other treating water pumped in from any of nine wells, with a design capacity of 2.5 mgd. These plants are of conventional design for chemical treatment, coagulation and filtration, with aeration for the well water. The chemicals in use are chlorine, ammonia, alum, ferric sulphate, lime, soda ash, and Calgon, all machine-fed.

These plants are operated by women operators who make all chemical tests, control treatment and handle all chemicals, except the connecting to feeders of chlorine and ammonia cylinders. On duty, on each shift, is one male operator, directly responsible for the operation of the entire water supply system during the period of his watch. While this male operator may advise the women operators as to the operation of the plant, he does not assist in the work required for the plant operation, such as handling the chemicals, making the tests, or cleaning the plant, but during periods of extremely bad conditions in the surface water treating plant, a male laborer is assigned to the plant for the purpose of keeping the chemical feeders filled.

The decision to use women operators in these filter plants was made in October 1942, and a number of women were selected from a group of several hundred trained production workers, some of whom had been continuously employed in our factories over a period of twenty years, but always during daylight hours. The filter plant work is shift work entirely. We could offer an increased rate of pay, however, an opportunity to do a man's work, but not to replace a man (our regular operators who were not in, or due for, service in the armed forces were needed on more important work) and the opportunity to break away from the monotony of a factory production job to one where individual ability to think and act was most necessary.

In making our first selection, about one hundred women who expressed an interest in the proposition were interviewed, shown the plants and informed as to the requirements of the position. Of the one hundred interviewed, eleven were chosen for immediate training in

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A paper presented on October 15, 1943, at the Philadelphia Conference of the Four States Section and Pennsylvania Water Works Operators Assn., by Robert J. Stewart, of the Service Div., Edgewood Arsenal, Md.

the 2.5 mgd. plant. Upon arrival at the plant they were given a short talk on water; its treatment; the responsibility of an operator to supply a sufficient amount of properly treated water; the care and operation of the plant equipment. Most of this discussion was completely over the heads of the group, but it did result in creating a desire to learn.

The women were then seated at a large table, shown the chemical tests made during the operation of the plant, supplied with equipment and chemicals and instructed in the making of the tests. These tests included alkalinity, CO_2, soap hardness, pH value, chlorides, total iron, manganese, color, turbidity, phosphate, and bottle tests of chemicals required for plant operation. Several copies of *"Water Purification for the Practical Man,"* by Charles R. Cox, were supplied for reference and qualified operators were constantly available to answer such questions as could not be answered within the group.

After one week of observation of plant operation, discussion among themselves and with the plant operators, and continued use of the tests, this group was most surprisingly conversant with the subject. The same procedure was continued for another week and one week was devoted to simple hydraulics of plant operation, and the care and operation of plant equipment.

During the three weeks training period, a number of other women had been selected who followed along with the original group and learned from them the earlier instructions. The number of women then available permitted the formation of operating shifts, and were immediately assigned to plants. In selecting candidates for these shifts, care was taken that the members of the group had equal mental and physical capability and that they were congenial. Of the original eleven, two are now plant supervisors, eight are shift heads, and one is responsible for boiler feed water treatment in eight plants containing thirty boilers ranging in size from 200 to 1,000 boiler hp.

In later training courses, the procedure was reversed. The candidates were first put to work cleaning the plant, then they were taught to operate valves, wash filters, handle chemicals, etc. Laboratory instruction was last in the course. This developed a better attitude toward the job than was the case when laboratory work was taught first and the cleaning operations left to the end.

Now, a word as to the water handled in these plants: In the surface water treating plant, the turbidity varies from 10 ppm. to more than 10,000 ppm. but the plant effluent will average less than 0.5 ppm.; the color varies from 5 to 300 ppm., with an average effluent of less than 5 ppm. The algae conditions during past summer were very bad, requiring a blacking out of the sedimentation tanks during bright days and a liberal use of charcoal; on several occasions manganese caused trouble.

In the well water treating plant, conditions are more uniform and not much variation in the treatment of the water is required, the chemical feeders varying with the rate of flow; but this plant has a clear well with a capacity of 1.0 mgd. and pumps with a combined capacity of 8.0 mgd. to care for high peak demands.

The question might be asked as to how women would react in an emergency which could only be answered

by an actual experience. Two incidents have occurred which might serve to indicate the possibilities. Shortly after the women had been placed on their own, a call was received that one of the filters was overflowing and flooding the plant. The operators did not know what to do. In this case, a wash water valve had been left open and upon washing another filter, the first filter which was not operating had overflowed. The operator had pushed the remote control button on the wash pump and thought it had been shut down. This flooding of the filter was one of those things which makes for experience, and was a lesson to all the women but a rather sad one for those in charge who had to listen to much caustic comment. In the second incident, the male operator was present in a plant when the fusible plug on a chlorine cylinder blew out, filling the plant and surrounding area with gas. There were three women operators present and all put on their gas masks but the male operator was much concerned about their remaining in the area and tried to eject them, to which they objected. They felt it was their duty and right to return to the plant with him and help remove the cylinder to the stream. In this instance, there was a short period of near panic, soon replaced by a sense of duty. Incidentally, I might state that previously all of the women operators had been employed in the manufacture of gas masks, and they are all well-trained in use of this equipment.

At this time, these women have been with us as plant operators for one year, and the arrangement has been highly satisfactory, the women being capable and willing workers within the limits of their physical ability, and under considerate and intelligent supervision. In accuracy of operation, and attention to details, the results are better with women than with men; but men are more interested in the mechanical parts of the operations and more capable in handling them. Women are most conscious of the appearance of the plant and as a result of their efforts in this direction, they receive much commendation from official visitors.

It is my opinion at this time that the most satisfactory water plant operation can be obtained through the use of mixed shifts, provided that the selection and release of personnel could be made without restrictions.

Job Classification in Municipal Water Works

By Albert R. Davis

THERE is a trite saying in regard to management that if you desire success you must be able to organize, delegate, and supervise, with emphasis on "organize." In the past, an organization may have been operated through common knowledge of what was to be done by individuals in the company capable of expanding with their jobs; but at best it was a poor substitute for proper organization. Today, due to the war, there is such a rapid turnover of personnel that serious consideration of a planned organization cannot be overlooked. Heretofore, we may have had capable and trained employees in the organization or available from outside sources; *but we can no longer take these conditions for granted.*

In attacking the many organizational problems that are besetting management today, we find some solace in the philosophy of Frederick W. Taylor, the founder of *scientific* management. In 1885 Taylor, as then a machinist, began his work at the Midvale Steel Works near Philadelphia. He became a factory manager and, later, a consulting management engineer. His theory (1) has been stated as the deliberate compilation of the vast amount of traditional knowledge which, in many cases, will result in laws, rules, and even mathematical formulae. When these laws, rules, and formulae are applied to the everyday duties of workmen, the invariable result is a much larger, as well as a better and higher quality of output per man. This system is the grandfather of our present day merit systems.

We who have been without merit systems, or at least up-to-date workable classification plans, find that we are being slowed down by having to study positions to determine the very minimum of qualifications that will be required to fill them. Our jobs have to be analyzed to find out where we have combined skilled and unskilled duties in one job, and if this has been done we shift our skilled man to a skilled job; the unskilled duties can be added to another unskilled job. Today we are acutely aware of the statements regarding personnel administration made by Dale Yoder "Actually, all managers (or superintendents, as we would say) are personnel managers, whether or not they recognize that fact or desire to be so regarded, for everyone who is called upon to assume managerial or administrative responsibility, in however slight degree, must at the same time assume responsibility for the personnel and policies involved" (*2*).

A paper presented on June 15, 1943, at the Cleveland Conference, by Albert R. Davis, Supt. of Water Dept., Austin, Tex.

Merit System

Since the management of a water works is largely a matter of satisfactory organization, the official in charge must organize his department so that he may secure maximum relief from dealing with employee difficulties and, at the same time, have adequate assurance that they are being properly adjusted. This requires zealous efforts to eliminate political, religious, and other extraneous factors, also it requires the establishment of a complete system of personnel administration built on sound legal authority.

Objectives

An organization that has the following objectives (3) may feel reasonably sure that the proper footings have been laid to support the building of such a system:

(1) Secure the most competent persons available for all positions in the department.

(2) Provide an attractive career in the service with opportunity for promotion, salary advancement, and retirement.

(3) Develop a salary and wage plan which compares favorably with other public and private employment and assures equal pay for equal work.

(4) Facilitate promotion, transfer, salary increases, recognition, and other rewards based upon demonstrated performance and capacity.

(5) Provide for separation of unsatisfactory employees.

(6) Promote the training of employees.

(7) Supervise the establishment of standards of performance, work incentives, and evaluation of the quality of the service rendered by the employees.

(8) Inquire into and secure necessary action in case of complaint against departmental employees.

(9) Investigate and initiate improvements in working conditions, and safety measures.

(10) Afford ready opportunity for employees to present their grievances, individually and collectively, to directing officials, and to enable employees to play a cooperative part in determining administrative policy and procedure.

The achievement of the above objectives involves a thorough study of existing conditions and the installation of a complete personnel, or merit, system. The studies to be made in developing such a system should include the following: (a) job classification (b) employee training (c) morale and conditions of employement (d) salary and wage plan (e) promotion and transfer (f) discipline (g) retirement system (h) recruiting and selection (i) certification of eligibles (j) employee relations (k) special problems. All of these should be discussed, but because our time is limited, we will select only the first and most important subject on this list, that of job classification.

Job Classification

The foundation of any comprehensive personnel system is a sound classification plan. Designed to establish and maintain a close relationship between necessary qualifications, duties and responsibilities, wages and salaries such a plan is a means of determining the nature and level of various jobs in the organization and analyzing the duties and responsibilities involved. Similar positions may be identified and allocated to the proper classification, regardless of department. This procedure will result in reducing to manageable proportions the information concerning the duties and responsibilities of positions. Classification will simplify the recruiting and

selection of qualified personnel, facilitate budgeting for personnel services, form a basis for a salary and wage plan, assist in measuring performance, and provide logical channels for promotion and transfer. Briefly a classification plan consists of (1) grouping into classes those positions of approximately equal difficulty and responsibility, which call for the same qualifications and compensation (2) writing specifications for each job in the department by giving descriptions of the position, the duties to be performed, and the qualifications required (3) listing the class titles held by each employee.

Salary Plan

Related to the classification plan is the salary and wage plan. The compensation for each class has a bearing on every other class; there must of necessity be an orderly progression of salaries from laborer to the department head. A sound salary and wage plan will provide for:

(1) A level of pay that will attract and keep qualified employees.

(2) Salary rates based on difference in duties, responsibilities, qualifications, and experience.

(3) Similar types of work to receive equal pay.

(4) Employees in the lower brackets to receive a decent minimum living wage.

(5) A sufficient salary range in each class to permit advancement in recognition of efficiency and length of service.

(6) Revision of salary ranges to reflect prevailing rates.

(7) Consideration of the water works financial capacity in relation to service needs.

This salary plan is a very important phase of a classification plan, and upon it relies the ability of water works to secure and retain valuable employees.

Excellent instructions for the development of the classification plan are set forth in a book *Municipal Personnel Administration* published last fall by the International City Managers Association (4).

Importance of Titles

It should be brought out here that the selection of titles *is* important. Each title should be brief and should be representative of the job itself.

Recently a questionnaire was sent out by the writer to cities of over 30,000 population to determine pertinent data concerning titles, personnel, and general information. At this time it is fitting that recognition be given of the wonderful cooperation received from 64 water departments that spent much time and energy filling out a tiresome questionnaire. This in itself is definite evidence of the progressive and unselfish attitude of the water works profession. (*See p. 1443, 1444.*)

Thus, we might say that the title of superintendent, since it received 50 per cent of the votes, should be acceptable. Based upon a percentage of usage this is a logical conclusion, but since we are trying to build up a list of titles that will be descriptive of the work and responsibilities involved, it does not rate so highly. In this list thirteen (20 per cent of the votes) are titles which indicate the influence of the engineering trend, while eleven (17 per cent of the votes) are managerial titles. The political influence is apparently on the wane having polled only six votes (9 per cent of the total). Since eight titles and 20 per cent of the votes represented the engineer-executive trend, it would appear that

Chief Executive—20 Titles

32 superintendent
6 manager
4 water commissioner
3 city engineer
2 superintendent and engineer
2 chief engineer
2 superintendent-engineer
2 chief engineer and general manager
2 general manager
1 general superintendent and engineer
1 superintendent and general manager
1 superintendent water and sewage department
1 assistant engineer
1 division engineer
1 water works engineer
1 executive manager
1 director
1 director of water
1 commissioner of public property
1 commissioner of public utilities

Chief Accounting and Collections—25 Titles

15 office manager
9 chief clerk
5 registrar
4 chief accountant
2 auditor
2 cashier
2 secretary of board of trustees
1 secretary and treasurer
1 secretary-cashier
1 treasurer
1 manager
1 secretary and assessor
1 controller and chief accountant employee
1 secretary
1 principal water clerk
1 water works clerk
1 assistant engineer
1 supervisor assessment section
1 superintendent of accounts
1 utilities business manager
1 supervisor of accounts and collections
1 commissioner of collections
1 office supervisor
1 superintendent of water office
1 treasurer and auditor

Top Man Purification-Treatment Plant—24 Titles

13 chemist
6 superintendent of filtration and chemist
3 supervisor of filtration
3 sanitary engineer
2 superintendent of purification; chemist
2 supervising chemist
2 superintendent of filtration
2 purification engineer
1 chief operator and water superintendent
1 bio-chemist
1 superintendent of water treatment
1 engineer-chemist
1 production engineer
1 director of purification
1 laboratory technician
1 city chemist
1 bacteriologist
1 plant chemist
1 chief operator and chemist
1 chief chemist
1 plant foreman
1 filterman
1 water shed inspector
1 chief chemical engineer

Distribution System Head—24 Titles

6 engineer
5 distribution engineer
5 assistant engineer
3 superintendent of water distribution
3 city engineer and water superintendent
2 civil engineer
2 superintendent
2 chief engineer
1 construction engineer
1 assistant superintendent
1 pipe laying inspector
1 assistant engineer pipe extensions
1 office engineer-superintendent of waterworks
1 distribution foreman
1 principal assistant engineer
1 field engineer
1 draftsman
1 assistant chief engineer and superintendent
1 city engineer
1 supervisor of distribution
1 distribution superintendent
1 principal waterworks engineer
1 senior civil engineer administrator
1 department manager and chief engineer

Meter Reader—9 Titles

54 meter reader	1 waterworks inspector and collector
2 meterman	1 inspector
1 meter foreman	1 chief meter reader
1 senior meter reader	1 meter inspector
1 meter reader and inspector	

Supervisor Meter Repairs—16 Titles

22 meter shop foreman	1 supervisor of meters
6 meter repairman	1 meter mechanic
6 meter foreman	1 assistant superintendent
5 foreman	1 storekeeper
2 superintendent of meters	1 general foreman
2 chief repairman	1 yard foreman
1 superintendent of water meters	1 supervisor of meters and inspection
1 water repair meter shop foreman	1 meter repair shop foreman

Employee Replacing Stopped Meters; Miscellaneous Meter Trouble Work—32 Titles

8 meter repairman	1 water service utility man
4 service man	1 water meter and service inspector
3 meter trouble man	1 chief and meter repairman
2 meter shop foreman	1 meter repair helper
2 meter setter	1 outside meter repairman
2 meter foreman	1 meter tester
2 meter reader	1 meter repairman
2 water service man	1 meter inspector
1 assistant foreman	1 meter helper
1 meter mechanic	1 meter service man
1 investigator	1 meter changer
1 meter exchange man	1 repair man
1 meter maintenance man	1 meter reader inspector
1 inspector	1 meter service
1 meter set and remove	1 repair truck man
1 maintenance man	1 complaint man

additional thought should be given in that direction. Engineering titles are opposed primarily because of past usage of the term. What does the average person visualize when he hears the word "engineer"? Most likely it is a man wearing overalls, jumper and denim cap, at the cab window of a locomotive; or more rarely a man with field boots and Stetson hat squinting through a transit; or possibly the man who runs the local ice plant. These misconceptions, however, need not stop us in our efforts to find descriptive title. Water works in conjunction with other utilities, universities, professional engineers and engineering societies should assume leadership in establishing the use of titles in the water works field that indicate engineering influence. The type and quality of the work required of the top executive in water works is such that engineering training and experience are essential, and such positions should carry engineering titles.

The questionnaire consisted of brief descriptions of 50 different jobs throughout the water works field, with a blank space left for each town to fill in the title that they use for each particular job. General information was requested in regard to supply, pumping, purification, distribution, accounting; a few specific questions were asked about personnel. Of 64 replies received 60 cities reported on personnel

as follows: 20 (33 per cent) have a merit system 23 (45 per cent) have partial personnel studies.

A total of 78 per cent of the towns reporting have taken definite action in regard to the formation of a personnel system.

In regard to titles, it was our purpose to determine the extent of the use of different titles for the same position; results showed an average of twenty per job.

From the above seven jobs, which are representative of all of the positions of a water department it is obvious local influence has been uppermost in the minds of management in selecting titles. The interests of the water works profession as a whole has evidently not been a motive in the selection.

No doubt you have observed that there is a semblance of meaning to most of the titles listed. There a certain diversity in titles is necessary to correspond with various forms of government under which the water works operates; yet in your own minds you must be thinking, "no standardization," or at least, "lack of sufficient standardization."

Those who have installed merit systems know that any classification or salary plan must be constantly revised; it must be kept up-to-the-minute, must be constantly guarded against encroachment by forces that may try to use it for selfish purposes.

The United States Department of Labor has made extensive studies in every conceivable branch of private business. It has published a dictionary of education and occupational titles; they have published a five-volume study of the construction industry and a three-volume study of retail trade, but the municipal field has not been touched.

Selective service officials have indicated that the Dictionary of Titles has been very helpful in classifying registrants, and they have also noted a lack of standard information in the municipal field, including the water works.

Those of you present who have a complete merit system know the value of having such a plan. Others who have a partial plan are coming to see the necessity for bringing it to completion. We hope this discussion will stimulate others to get started.

If a city finds it advantageous to analyze, classify and list all positions, why would it not be well for the water works profession to do a little thinking about standardizing the personnel classification for the field at large? Such a study would have many advantages in that it would (1) clarify the language used by the water work profession in regard to the personnel—especially titles (2) it would provide basic information for present war needs (3) it would promote a better understanding between the administrative head of the department and the local government; (4) it would improve the esprit de corps in that it would establish among employees a feeling that each of them is a part of a national team; (5) it would act as a guide in the development of growing organizations (6) it would be an aid to keeping the local system up-to-date.

References

1. Petersen, Elmore & Plowman, Edward G. *Business Organization and Management.* R. D. Irwin, Inc. Chicago (1941).
2. Yoder, Dale. *Personnel Management and Industrial Relations.* Prentice-Hall, Inc., New York (1942).
3. Stone, Donald C. *The Management of Municipal Public Works.* Public Administrative Service, Chicago (1939).
4. *Municipal Personnel Administration.* International City Managers Assn., Chicago (1943).

A Proposed Mechanism for Breakpoint Chlorination

By John R. Rossum

IN view of the great interest in the practical and theoretical aspects of break-point chlorination, it is surprising that there has not been offered an explanation of the chemical mechanism involved.

Calvert (1) and others have shown that the typical "break-point" curve is due to the reaction between chlorine and amino nitrogen, and that there is a stoichiometric relationship between the chlorine and nitrogen. The overall reaction at the dip of the "break-point" curve is expressed by the equation:

$$3Cl_2 + 2NR_3 = 6RCl + N_2$$

Griffin (2) has shown that the shape of the break-point curve is dependent upon pH.

Chapin (3) demonstrated that the proportions of mono-, di-, and trichloramine were determined by the pH in the *presence of excess ammonia.* In break-point chlorination, however, the ammonia is not in excess and the controlling factor as to which of the chloramines is formed is the ratio of chlorine to ammonia. This may be demonstrated by writing the mass action expressions for the following equations:

(a) $Cl_2 + NH_3 = NH_2Cl + HCl$

(b) $2Cl_2 + NH_3 = NHCl_2 + 2HCl$

with the corresponding mass action expressions:

$$\frac{(NH_2Cl)(HCl)}{(Cl_2)(NH_3)} = K'$$

$$\frac{(NHCl_2)(HCl)^2}{(Cl_2)^2(NH_3)} = K''$$

where the parenthesis indicate the molal concentration of the quantities enclosed. Actually molecular Cl_2 and NH_3 exist in water in very small concentrations, dissociating into H^+, Cl^-, OCl^- and HOCl, and OH^-, NH_4^+, and NH_4OH respectively. The concentration of each ion is dependent on a variety of factors, the most important of which are the original concentrations of chlorine and ammonia, the pH, and the temperature. The above equations may then be written more accurately as:

$$\frac{(NH_2Cl)}{(Cl_2)(NH_3)} = K'$$

$$\frac{(NHCl_2)}{(Cl_2)^2(NH_3)} = K''$$

and may be combined to:

$$\frac{(NHCl_2)}{(NH_2Cl)} = \frac{K''(Cl_2)}{K'}$$

where K' and K'' are constants at any given temperature and pH. Similar expressions may be written for trichloramine, but for purposes of sim-

A contribution by John R. Rossum, Junior Engineer of Water Sanitation, San Diego Water Dept., San Diego, Calif.

plicity, they will not be considered in this discussion.

If chlorine and hydrogen are given their conventional valences of -1 and $+1$ respectively, it will be noted that in the compound NH_2Cl, the nitrogen must have a valence of -1 in order to balance the positive and negative charges in the molecule. By similar reasoning, the nitrogen atom in $NHCl_2$ must have a valance of $+1$. Since these nitrogen atoms have opposite charges, it is proposed that they would have a strong tendency to react to form neutral nitrogen gas according to the equation:

$$\text{(c)} \quad NH_2Cl + NHCl_2 \rightarrow N_2 + 3HCl$$

Reaction (c) is assumed to be irreversible and fairly slow, its rate depending upon the product of the concentration of the mono- and dichloramines, the temperature, and the illumination. By similar reasoning, it can be shown that trichloramine will react with monochloramine.

Reactions (a) and (b) are assumed to be very rapid in the direction in which they are written and very slow in the reverse direction. These assumptions seem to be justified by the thermodynamic data available, although, as expected, they are meager. By assuming values for K' and K'' and making use of the relationship that,

$$(NH_3)_o = (NH_3)_n + (NH_2Cl)_n + (NHCl_2)_n$$

(where the subscript o denotes the original concentration of ammonia, and the subscript n the concentrations after n mols of chlorine have been added), it is possible to calculate the concentrations of mono- and dichloramine with increasing quantities of chlorine. These calculations are rather tedious and will not be presented here, but the results of such calculations are shown by the curves (Fig. 1).

After reaction (c) has gone to completion, the chlorine residual to the right of the dip in the break-point curve will be equal to the remaining monochloramine plus any unreacted chlorine.

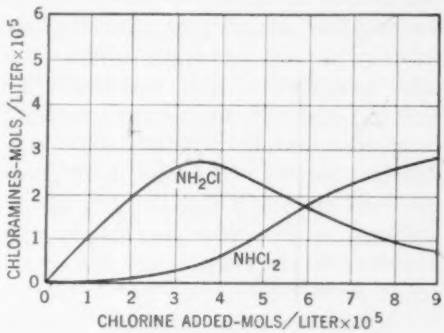


FIG. 1

The unreacted monochloramine will be the original monochloramine minus the original dichloramine. To the right of the dip, the chlorine residual will be equal to the unreacted dichloramine plus any unreacted chlorine.

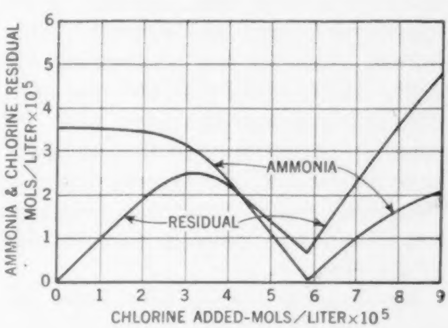


FIG. 2

The unreacted dichloramine will again be the difference between the original dichloramine and the original monochloramine concentrations. Since the concentration of the unreacted chlorine is small, the chlorine residual

curve is essentially the difference between the monochloramine and dichloramine concentrations. A typical break-point curve is obtained when the above calculations are performed and the results are plotted (Fig. 2). It will be noted that the residual does not fall to zero at the dip. This is due to the fact that in order to make the calculations, it was necessary to make the false assumption that reactions (a) and (b) were "frozen" after reaching completion while reaction (c) was still in progress. Actually, both chlorine and ammonia will be zero at the break-point in order to satisfy the equilibrium demanded by the mass action expressions.

The ammonia concentration curve is also shown in Fig. 2. This includes the ammonia and the ammonia combined as chloramine. The curve to the left of the break-point is quite similar to that found experimentally by Griffin (2). On the right of the dip, it is expected that the errors introduced by the assumption mentioned above would be of great magnitude, especially after considerable time had elapsed. This follows from the law of chemical kinetics which states that the rate of a chemical reaction increases with increasing concentration of the reactants; nevertheless, both the experimental and theoretical results show that amino nitrogen tends to increase on each side of the dip.

Break-point curves have been obtained experimentally using more complicated amines than ammonia. Calvert (1) obtained typical curves using amino-acetic acid. The author has obtained typical curves using analine, a primary amine, and di-methyl-amino-benzaldehyde, a tertiary amine. Indole-acetic acid failed to give a typical break-point curve, but this compound does not contain an amino nitrogen atom.

The importance of illumination in the rate at which reaction (c) proceeds can hardly be overemphasized. At Lockwood Mesa Reservoir on the San Diego City water supply, break-point chlorination is being used. The chlorine residual from the reservoir effluent drops markedly during the day and rises again at night. The low point on the curve corresponds with the time that the sun is directly overhead. Furthermore, the drop is much less in winter than in summer. The taste of the water varies directly with the chlorine residual although the taste is not due to chlorine as shown by the fact that when lower doses of chlorine are used, the taste is more pronounced. It is obvious, both from the taste of this water and from the chlorine residual, that break-point chlorination is being achieved only when the sun's rays strike the water at something less than the angle of total reflection. Laboratory experiments have also demonstrated that the break-point reaction occurs much more rapidly when the solution is illuminated than in the dark.

From the foregoing observations it may be assumed that amino nitrogen is completely destroyed at the break-point. This accounts for the great value of break-point chlorination in eliminating tastes and odors in certain water supplies, and leads to an interesting speculation that may be of major importance in helping to solve another problem that besets water treatment plant operators.

Frequently the water leaving a treatment plant may be of excellent quality, but on reaching the far ends of the distribution system after many hours of sluggish flow, tastes and odors due to bacterial growths in the pipelines

cause many complaints. By removing all amino nitrogen before the water enters the distribution system, pipeline growths would be greately inhibited both by decreasing the available food supply and by destroying some of the essential growth factors such as thiamin and the amino acids. Since very small concentrations of the growth factors are required for development of bacteria, it is quite possible that they may be present in the water in quantities too small to permit the use of break-point chlorination, yet great enough to cause troublesome growths. In this case, the addition of ammonia will permit an increase in the chloramine concentrations so that reaction (c) will occur at a sufficiently rapid rate. This method has been used by Harvill, Morgan and Mauzy (4) and has been designated by them as "ammonia-induced break-point chlorination."

The author gratefully acknowledges a very helpful discussion with Dr. W. C. Bray and Dr. K. S. Pitzer of the Chemistry Department of the University of California, Berkeley, California, in the early stages of this work.

References

1. Calvert, Cecil K. Super-Chlorination. W.W.&Sew., **87**: 299 (1940).
2. Griffin, A. E. Conditions Affecting the Formation of Chloramines. Jour. A.W.W.A., **33**: 2088 (1941).
3. Chappin, Robert M. Dichloro-Amine. J. Am. Chem. Soc. **51**: 2112 (1929).
4. Harvill, Clyde R., Morgan, J. H. & Mauzy, H. L. Practical Application of Ammonia-Induced Break-Point Chlorination. Jour. A.W.W.A., **34**: 275 (1942).

Contamination of Water Supplies in Limestone Formation

By S. P. Kingston

FOR many years the Minnesota Department* of Health has recognized the dangers associated with obtaining water supplies from wells and springs situated in limestone formations. The *Manual of Water Supply Sanitation* of the Department contains the following statement: "There is common belief that contamination may seep through the soil for long distances and get into a well in this way, but such is not generally true in Minnesota although it should always be considered a possibility." The possibility exists in a portion of southeastern Minnesota where cavernous and fissured limestone formations lie relatively close to the ground surface, particularly at higher elevations.

In that portion of Minnesota (Fig. 1) where limestone formations are situated close to the ground surface, special precautions must be taken to protect ground water supplies from underground contamination. The black portion of the map (Fig. 1) indicates an area in which sinkholes predominate. The sinkholes are generally situated over the Galena limestone formation and are nothing more than openings or broken down spots in the loam or drift that connect directly to the limestone (Fig. 2, 3). They allow surface drainage, and in many cases domestic sewage and industrial waste, to enter the limestone. The sinkholes vary in diameter and depth from a few feet to over 100 ft.

The vertical and horizontal channels of the limestone quarry, indicate how easily contamination can travel great distances in the rock. In many cases contamination can, and has, entered municipal and private water supply systems.

A Typhoid Fever Outbreak

A little over five years ago, District No. 3 of the Minnesota Department of Health was organized with headquarters at Rochester. It was obvious at that time that one of the problems to be given special study was the possible contamination of municipal and private water supplies situated in the limestone area. Particular emphasis was given to the study when eleven cases of typhoid fever and one death occurred during the summer and fall of 1939 and the spring of 1940, in and adjacent to a village in Fillmore County (Fig. 4).

The first three cases developed at a farm in the southern portion of the village. The water supply for this farm was obtained from the village

A paper presented on March 13, 1943, at the Minnesota Section, by S. P. Kingston, Public Health Engr., State Dept. of Health, Rochester, Minn.

water supply system and from a drilled well situated on the farm. The farm well which may be designated as well "A" was apparently cased only to the

FIG. 1. Limestone and Sinkhole Area

first rock formation. This provided no protection from underground contamination.

A few weeks later five cases of typhoid fever occurred in the village. All of these persons had been using water supplied by the municipal system. The municipal supply is taken from two drilled wells which are designated as the old and new municipal wells. The old well is approximately 270 ft. deep and is cased only to the first rock formation. The new well is 1126 ft. deep and is cased to a depth of 400 ft. with 10-in. casing, to 340 ft. with 12-in. casing and to 20 ft. with 16-in. casing. All are cement-grouted in place for the purpose of excluding underground and surface contamination (Fig. 5).

In the spring of 1940, three more cases of typhoid fever occurred at a farm situated about two miles northwest of the village. The water supply for this farm was obtained from a drilled well cased only to the first rock formation. This well is designated as well "B" (Fig. 4).

At the time the typhoid fever cases occurred it was known that the village was discharging partly treated sewage into a sinkhole situated about 1500 ft. south of well "A" and 4000 ft. south of the municipal wells.

A complete epidemiological investigation disclosed no typhoid fever carriers with whom any of the cases had been in contact and no common vector other than the water supplies was found. However, the public health engineering work done in connection with the investigation revealed the following facts:

(a) Fluorescein dye (about three pounds) was introduced into the sinkhole receiving approximately 60,000 gpd. of partly treated sewage from the village. Periodic sampling was carried out at wells "A" and "B," and the two municipal wells. Within four hours the fluorescein dye appeared in water samples collected from well "A," a distance of approximately 1500 ft. from the sinkhole. However, no indica-

FIG. 2. Typical Sinkhole

tions of the dye were obtained from the samples of water collected from well "B" or the municipal wells. Bacteriological examination of water samples collected from well "A" showed a maximum concentration of 900,000 coliform organisms per 100 ml. as determined by the most probable number test.

(b) Just previous to the onset of the typhoid fever cases in the village, the

FIG. 3. Limestone Quarry

old municipal well had been used during an emergency. All bacteriological samples collected from the old well, over a period of several months, contained coliform organisms with a maximum concentration of 1600 per 100 ml. At no time was any contamination found in the water obtained from the new municipal well.

(c) Bacteriological examination of samples obtained from well "B" showed a maximum concentration of 92,000 organisms per 100 ml. In addition, typhoid organisms (*Eb. typhosis*) were isolated directly from 20-gal. water samples collected from the well. This indicated that excreta from a typhoid case or carrier were getting into the well. However, the investigation did not reveal the exact location at which domestic sewage was entering the limestone formations.

The foregoing engineering findings indicate that the eleven typhoid fever cases probably were water-borne and that infectious organisms had been transmitted through the cavernous and fissured limestone formations. Engineering recommendations were made to the municipality and to the individuals affected, as to methods of providing satisfactory water supplies and proper methods of sewage disposal.

Investigation of Farm Water Supplies and Sewerage Systems

The field work in connection with the typhoid fever outbreak, indicated the desirability of investigating a large number of farm water supplies and sewerage systems in the township immediately adjacent to the village. The investigation was conducted during the summer of 1941. The principal objects were to discover additional sources of contamination that may have contributed to the typhoid fever outbreak; and to collect engineering data on each water supply system. A total of 145 investigations were made at 13[illegible] farms. A summary of this investigation revealed the following:

(1) The major portion of all water supplies was poorly constructed above and below ground surface. Well casings in general were terminated at the first rock formation, thus providing no

protection from surface contamination that might enter the limestone.

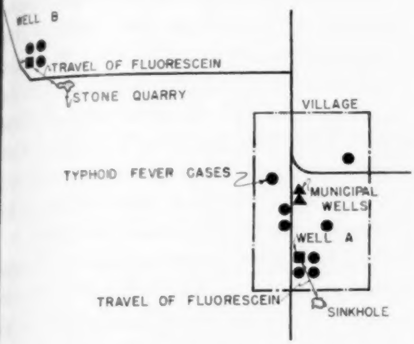


FIG. 4. Location of Wells, Typhoid Fever Cases, Sinkhole and Stone Quarry

(2) The bacteriological examination of 206 water samples collected during the course of the investigation showed 77 per cent of the supplies to contain coliform organisms; 20 per cent showed concentrations in excess of 100 organisms per 100 ml.; and 12 per cent were in excess of 1600 per 100 ml. In a few cases where it was possible to repeat sampling, there was an indication that the bacteriological counts increased after rains, showing that surface contamination was entering the wells.

(3) Approximately thirty-five of the farms were served with water-carriage toilet systems. Of these, 50 per cent were known to discharge sewage directly into the limestone formations, creating a serious hazard to the water supply for the farm, adjacent farms and municipalities.

(4) At a creamery, floor drainage was being discharged into a sinkhole approximately 150 ft. from the creamery well. Fluorescein dye (about 1 lb.) introduced into the sinkhole appeared in the well water within two hours, indicating a direct connection between the sinkhole and the well. It is needless to say that bacteriological results on samples collected from this well showed the water to be grossly contaminated.

(5) In an attempt to locate the source of contamination for well "B" fluorescein dye was introduced into an opening in the stone quarry (Figs. 3, 4). The opening had been used as a place of excreta disposal by the quarry employees. Within less than six hours the fluorescein dye appeared in a large spring situated approximately 100 ft. from well "B" and 1600 ft. from the quarry. The spring had been used for a drinking water supply up until the time well "B" was contructed. While

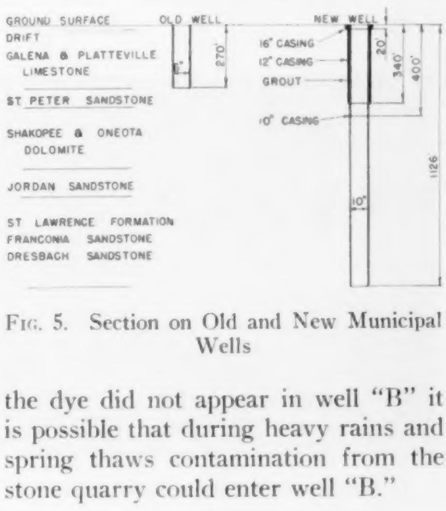


FIG. 5. Section on Old and New Municipal Wells

the dye did not appear in well "B" it is possible that during heavy rains and spring thaws contamination from the stone quarry could enter well "B."

Contamination of Water Supply

Another very interesting case of water supply contamination occurred during the summer of 1942, at a large private residence in Olmsted County. The situation was brought to the attention of District No. 3 after several cases of gastro-enteritis developed in persons visiting the residence. The cases appeared to be of a water-borne nature.

Plans and specifications for the residence, completed in the fall of 1941, showed the proposed location of the well and specified only that a certain amount of water per minute be obtained. No other well specifications were given. The well driller provided a 6-in. well 198 ft. in depth, cased only 8 ft. into the Platteville limestone, thus giving very little protection from underground contamination.

The plans indicated a septic tank and leaching pit situated approximately 110 ft. from the well. The plumber installed the septic tank in the creviced Platteville limestone and to provide a method for final disposal of the effluent a leaching pit was blasted in the rock (Fig. 6).

FIG. 6. Platteville Limestone

The engineering investigation revealed the water supply to have an odor of organic matter, indicating the probability of sewage contamination from the leaching pit. Again fluorescein dye was used. About one pound of the dye was introduced into the leaching pit and in less than fourteen hours the well water turned a deep green, indicating a direct connection between the leaching pit and the well (Fig. 7). This finding was substantiated by bacteriological results.

Immediate steps were taken to correct this situation. The use of the well was discontinued and a new drilled well was constructed (Fig. 8). The new well is 285 ft. deep and is cased with 8-in. casing to a depth of 145 ft. The 8-in. well casing was placed in a 16-in. drill hole and the annular space between the casing and the drill hole was filled with cement grout. A cast-iron sewer was provided for the effluent from the septic tank and a soil absorption system constructed in suitable soil about 250 ft. from the well. When all construction work was completed on the new well and sewerage system, the old well was filled with concrete and the old leaching pit filled with clay.

Contamination of Municipal Water Supply

The investigation of the contamination of water supplies situated in the limestone area, of course, included all of the municipal water supplies. Most of the municipal water supplies are obtained from deep wells but a few large springs are used. The springs are apparently subject to surface drainage through sinkholes, etc. This occurs during periods of heavy precipitation and spring thaws when the water becomes turbid and the concentration of coliform organisms increases. One very large spring, although not used for a municipal water supply, is clear during normal weather conditions but during periods of heavy rains becomes extremely turbid and occasionally straw and corncobs appear in the water, indicating a direct connection to the ground surface.

In the spring of 1942 during an investigation made of a municipal water

supply derived from a typical limestone spring, it was reported that there had been several cases of gastro-enteritis during the preceding month, particularly during a period when the water had been turbid.

To confirm these reports a survey was made by visiting every fifth household in systematically selected sections of the village to determine the incidence of gastro-enteritis during the preceding month. Seventy-two households were visited and information obtained from 274 persons, or approximately 13 per cent of the population. The survey indicated that an outbreak of gastroenteritis affected approximately 10 per cent of the population during a thirty-day period. Many of the individuals questioned associated their illness with the time when the water supply was turbid and unsatisfactory for domestic use.

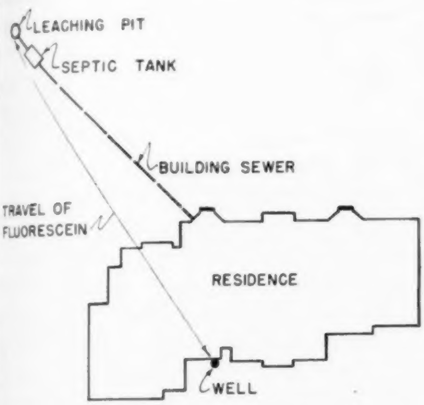


Fig. 7. Location of Well and Leaching Pit at Private Residence

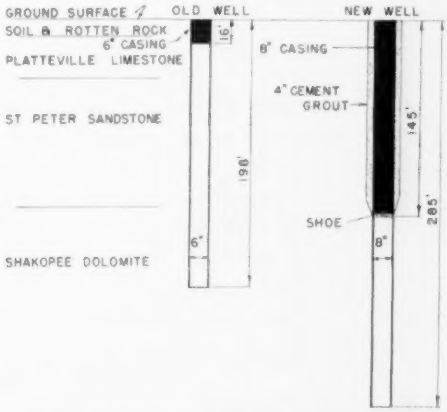


Fig. 8. Section of Old and New Wells at Private Residence

Summary

The main purpose of this report has been to discuss some definite instances where municipal and private water supplies obtained from limestone formations, have been seriously contaminated, and not to propose any detailed methods of correction. However, it is probably advisable to summarize the more salient features and to formulate broad corrective measures as follows:

(1) It is obvious that there is real danger of underground contamination of municipal and private water supplies situated in the fissured and cavernous limestone area of southeastern Minnesota. This is borne out by the fact that on four separate occasions underground sewage flow was traced, with the aid of fluorescein dye, up to a maximum distance of 2000 ft. and in every case the dye was recovered from a water supply that had been used for drinking purposes. In connection with a typhoid fever outbreak it was possible to isolate pathogenic organisms (*Eb. typhosis*) directly from a well water supply.

(2) A very large portion of farm or private water supplies are of unsatisfactory construction and are further endangered by the practice of discharging sewage directly into the limestone formations.

(3) In the development of under-

ground water supplies great care should be exercised in the selection of well locations, the use of impervious overlying geological strata and special structural features to exclude underground contamination. Municipal water supplies should be provided with subsequent treatment as required.

(4) Water supplies that are obtained from springs in the limestone formations should be considered as surface water supplies and be provided with adequate treatment.

(5) The practice of discharging sewage into the limestone formations should be eliminated.

Mechanical Joints for Water Lines

By Elson T. Killam

THE use of mechanical joints for pipelines is by no means of recent adoption, such joints having been widely used with plain-end pipe on oil and gas lines for over fifty years. Their use in the water works field prior to 1920, however, was confined primarily to clamps and couplings for repair and emergency cases and miscellaneous hook-ups. Fortunately, some water lines were installed with mechanical joints in scattered locations during earlier years, and these now afford valuable data on performance. About 1930 they came into general use in the water works field, due primarily to the increased use of steel pipe for water lines, and the adoption of permanent linings.

Among the principal factors in jointing of water pipelines are, (1) flexibility (2) water-tightness (3) cost. Seldom will any one factor control the selection of alternate joint types; coincident evaluation of all three factors is desirable.

Flexibility is of major importance from the standpoint of expansion and contraction, vibration, relief of stresses created by settlement of foundation, changes in vertical or horizontal alignment with minimum use of specials. Many of these factors are interrelated with water-tightness, which is of major importance, particularly with long lines that involve relatively high cost of supply.

Included in the factor of cost are purchase of materials, the labor of installation, rate of laying progress, laying methods, and maintenance. Additional problems to be considered in the selection of joint type, are those relating to the use of pipe linings and coatings, and the special field conditions that will have to be encountered.

Some of the more important engineering features to be considered in the utilization of mechanical joints in the water works field are:

1. Details of Coupling Construction
2. Jointing Procedure
3. Flexibility
4. Water-tightness
5. Special Problems

Details of Coupling Construction

The sleeve-type coupling is the mechanical joint most widely used on water pipe.

A complete coupling consists of a middle ring, two rubber-compound gasket rings, and two follower rings connected by a set of bolts. Plain-end pipe is utilized for jointing with sleeve-type mechanical couplings. The middle ring is a sleeve which encircles both pipe ends at the joint; usually it has a pipe stop, or center bead, which

A paper presented on June 17, 1943, at the Cleveland Conference by Elson T. Killam, Hydr. & San. Engr., New York, N.Y.

serves automatically to center it over the abutting ends of the pipe (Fig. 1). The middle ring has flared ends, and when it is installed two triangular pockets are formed, the follower rings compressing the wedge section rubber gaskets into these pockets when the bolts are tightened.

panying chart (Fig. 2) shows the maximum allowable working pressure for standard couplings 4-in. id. to 26 od., inclusive, while Table 1 gives important design information on standard steel pipe couplings.

Where conditions warrant, couplings are field-coated with a thick bituminous

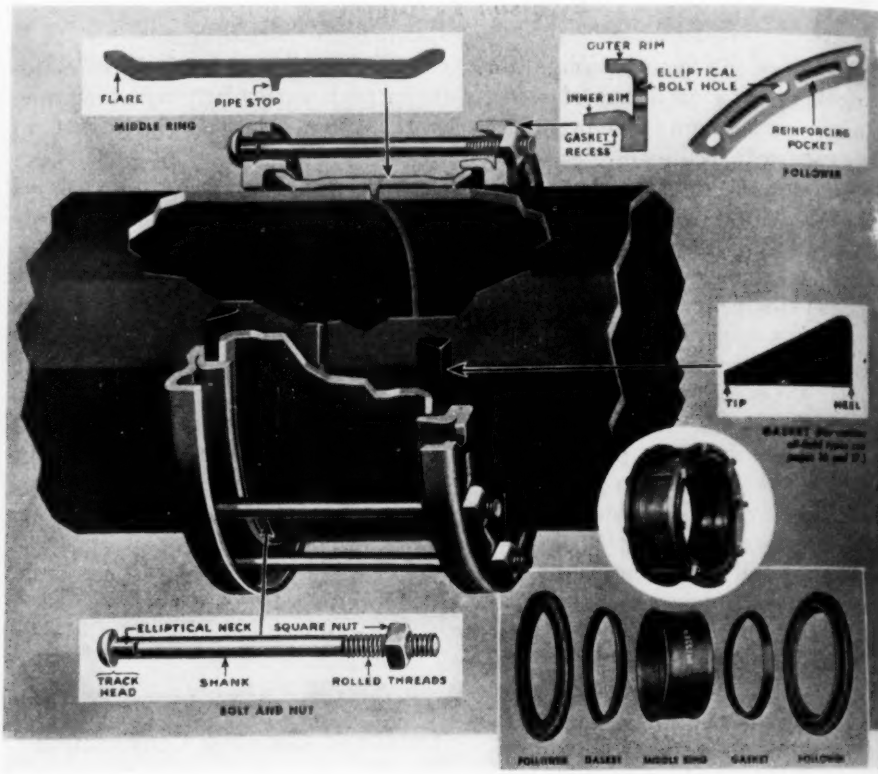


Fig. 1. Component Parts and Typical Cross-Section of the Sleeve Type Coupling

Standard couplings are suitable for pipeline working pressures up to 1500 psi., but special couplings for higher pressures can be furnished. Pressure rating of the coupling is based primarily on the strength of the middle ring, this strength being varied to suit specific pressures by altering the thickness, or by heat-treating. The accom-

material (Figs. 3–5). Metal parts are shop-coated with proper primer. Where pipe is mill-coated and wrapped, both coating and wrapping must be omitted at the ends for coupling installation, the ends being shop-coated with primer only.

The sleeve type of mechanical pipe coupling presents a particularly im-

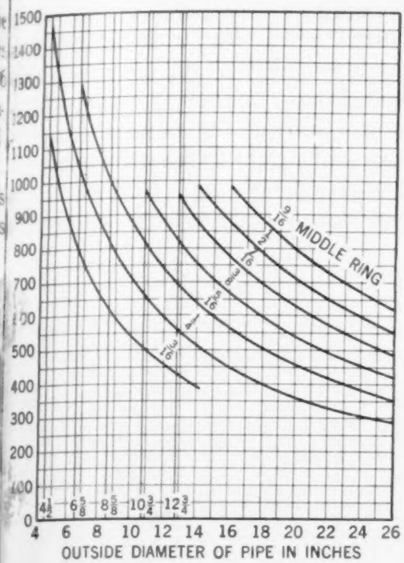


Fig. 2. Maximum Allowable Working ...essures for Standard Couplings 4-in. id. to ...in. od. Inclusive. The Pressure Values ...e Derived by Applying Barlow's Formula ... the Middle Ring With an Allowable ...orking Stress of 15,000 lb. psi.

...rtant advantage over other types of ...eel pipe jointing in connection with ...ater pipe installation, insuring a uni...ormly smooth mechanically-applied ...pe lining throughout the barrel of ...ach pipe section and preserving the ...uality of pipe lining at the joint. ...ther types of steel pipe jointing re...uire removal and hand-replacement of ...oth lining and coating for a total of ...bout 12 to 16 in. at each joint.

...asket Design

Gaskets for water service are of ...pecially compounded rubber and are ...vailable either plain or armored; as...estos gaskets are available for high ...emperatures. The design of all joints ...sing gaskets under compression is ...ased upon the fundamental principle ...hat the unit gasket pressure must al...ays exceed the line pressure if leakage is to be prevented; therefore, the ratio of gasket to line pressure represents the factor of safety.

Extended studies have been made of the behavior of gaskets under pressure, as a guide to improved design, and data are available to those interested as to the relation of wrenching torque and gasket pressures; effects of time upon gasket pressure; flow or deformation of gaskets under pressure and restraint of flow by the use of armored gaskets under special conditions.

Life of Gaskets

Those unfamiliar with rubber chemistry may question the longevity of rubber gaskets. Fortunately, they can be reassured by (1) records of actual performance of rubber gaskets (2) consideration of certain commonly recognized fundamental factors (3) reviewing the specialized investigation which has been applied to this problem.

Record of Performance

The use of rubber as a jointing material was reported in England in 1863 and in France and the United States as early as 1870. No report has come to my attention of gasket failure in the many repair clamps widely used for years in water works practice. The "liveliness" and resilience of a gasket after 28-yr. of service has been demonstrated by samples taken from old lines. Laid at Malta, O., in 1891, the first coupled natural gas line is still in satisfactory operation, and a water line at Bradford, Pa., laid in 1903, has given uninterrupted service to date. In neither of these cases has joint repair been required over the 40- to 50-yr. periods of service.

Published data in water works literature on the selection of compounds

for gaskets, are limited, whereas the gas industry has published many comprehensive articles on the subject.

It is well-known that elements such as sunlight, dry air, heat and tension, are harmful to rubber and are purposely avoided in gasket design. Rubber for gaskets is especially compounded for the particular service required of it, but it is also shielded from weather and light, and it is maintained moist and under heavy compression. Among the physical characteristics important to the compounding of gasket rubber are: Resilience, compression set, resistance to age, and

TABLE 1

Working Pressures and Detail Measurements of Standard Steel Pipe Size Couplings

Pipe Steel		Middle Ring	Followers	Bolts		Gaskets	Working Pressure
Nominal Size	Outside Diam.	Thickness and Length	Thickness	No.	Diam. and Length	Section Dimensions Thickness and Length	Max.
in. id.	*in.*	*in.*	*in.*		*in.*	*in.*	*psi.*
3/8	0.675	.120 x 3 1/2	3/16	2	3/8 x 5	11/32 x 5/8	1500
1/2	.840	.120 x 3 1/2	3/16	2	3/8 x 5	9/32 x 9/16	1500
3/4	1.050	.120 x 5	3/16	2	1/2 x 6 3/4	9/32 x 9/16	1500
1	1.315	.134 x 5	3/16	2	1/2 x 6 3/4	9/32 x 9/16	1500
1 1/4	1.660	.148 x 5	3/16	2	1/2 x 6 3/4	9/32 x 9/16	1500
1 1/2	1.900	.148 x 5	3/16	2	1/2 x 6 3/4	11/32 x 5/8	1500
2	2.375	.154 x 5	1/4	3	5/8 x 8	1/2 x 29/32	1500
2 1/2	2.875	.203 x 5	1/4	3	5/8 x 8	1/2 x 29/32	1500
3	3.500	1/4 x 5	1/4	4	5/8 x 8	1/2 x 29/32	1500
3 1/2	4.000	1/4 x 5	1/4	4	5/8 x 8	1/2 x 29/32	1500
4	4.500	1/4 x 5	1/4	4	5/8 x 8	1/2 x 29/32	1460
4 1/2	5.000	1/4 x 5	1/4	4	5/8 x 8	1/2 x 29/32	1330
5	5.563	1/4 x 5	1/4	4	5/8 x 8	1/2 x 29/32	1210
5	5.563	1/4 x 7	1/4	4	5/8 x 10	1/2 x 29/32	1210
6	6.625	1/4 x 5	1/4	6	5/8 x 8	1/2 x 1	1035
6	6.625	1/4 x 7	1/4	6	5/8 x 10	1/2 x 1	1035
8	8.625	1/4 x 5	1/4	6	5/8 x 8	1/2 x 1	811
8	8.625	1/4 x 7	1/4	6	5/8 x 10	1/2 x 1	811
8	8.625	5/16 x 5	5/16	6	5/8 x 8 1/2	1/2 x 1 1/8	1000
8	8.625	5/16 x 7	5/16	6	5/8 x 10 1/2	1/2 x 1 1/8	1000
10	10.750	1/4 x 5	1/4	8	5/8 x 8	1/2 x 1	660
10	10.750	1/4 x 7	1/4	8	5/8 x 10	1/2 x 1	660
10	10.750	5/16 x 5	5/16	8	5/8 x 8 1/2	1/2 x 1 1/8	815
10	10.750	5/16 x 7	5/16	8	5/8 x 10 1/2	1/2 x 1 1/8	815
12	12.750	1/4 x 5	1/4	8	5/8 x 8	1/2 x 1	561
12	12.750	1/4 x 7	1/4	8	5/8 x 10	1/2 x 1	561
12	12.750	5/16 x 5	5/16	8	5/8 x 8 1/2	1/2 x 1 1/8	694
12	12.750	5/16 x 7	5/16	8	5/8 x 10 1/2	1/2 x 1 1/8	694

TABLE 1—*Continued*

Pipe Steel		Middle Ring	Followers	Bolts		Gaskets	Working Pressure
Nominal Size	Outside Diam.	Thickness and Length	Thickness	No.	Diam. and Length	Section Dimensions Thickness and Length	Max.
in. od.	*in.*	*in.*	*in.*		*in.*	*in.*	*psi.*
14	14.000	1/4 x 5	1/4	8	5/8 x 8 1/2	1/2 x 1 1/8	513
14	14.000	1/4 x 7	1/4	8	5/8 x 10 1/2	1/2 x 1 1/8	513
14	14.000	5/16 x 5	5/16	8	5/8 x 8 1/2	1/2 x 1 1/8	635
14	14.000	5/16 x 7	5/16	8	5/8 x 10 1/2	1/2 x 1 1/8	635
16	16.000	1/4 x 7	1/4	10	5/8 x 10 1/2	1/2 x 1 1/8	451
16	16.000	5/16 x 7	5/16	10	5/8 x 10 1/2	1/2 x 1 1/8	559
16	16.000	3/8 x 7	11/32	10	5/8 x 10 1/2	5/8 x 1 3/16	666
18	18.000	1/4 x 7	1/4	10	5/8 x 10 1/2	1/2 x 1 1/8	402
18	18.000	5/16 x 7	5/16	10	5/8 x 10 1/2	1/2 x 1 1/8	500
18	18.000	3/8 x 7	11/32	10	5/8 x 10 1/2	5/8 x 1 3/16	595
20	20.000	1/4 x 7	1/4	12	5/8 x 10 1/2	1/2 x 1 1/8	363
20	20.000	5/16 x 7	5/16	12	5/8 x 10 1/2	1/2 x 1 1/8	452
20	20.000	3/8 x 7	11/32	12	5/8 x 10 1/2	5/8 x 1 3/16	538
22	22.000	1/4 x 7	1/4	14	5/8 x 10	1/2 x 1 3/16	331
22	22.000	5/16 x 7	5/16	14	5/8 x 10 1/2	5/8 x 1 3/16	412
22	22.000	3/8 x 7	11/32	14	5/8 x 10 1/2	5/8 x 1 3/16	491
24	24.000	1/4 x 7	1/4	14	5/8 x 10	1/2 x 1 3/16	304
24	24.000	5/16 x 7	5/16	14	5/8 x 10 1/2	5/8 x 1 3/16	378
24	24.000	3/8 x 7	11/32	14	5/8 x 10 1/2	5/8 x 1 3/16	452

Black Steel bolts are standard, but bolts may be cadium-plated, galvanized, or provided with either a metallic coating or other specified coating material.

packing ability. Extended studies and development of these characteristics have been aided by inspection of old gaskets; by conducting accelerated tests; by determination of physical properties, and by measurement of performance by means of specially developed instruments.

Those of us who recall the headaches involved in coaxing an optimistic total of 5,000 mi. from the tire of 30 yr. ago, and who have, until recently enjoyed practically uninterrupted service for five or six times this mileage, can testify to the progress in the field of rubber chemistry.

Of the utmost importance in the achievement of permanent watertight flexibility of mechanically-coupled joints, is the retained resilience of rubber-compound gaskets over a period of years. The life of the joint should equal the life of the pipe. This objective is attained by special compounding of the gaskets to provide optimum qualities, particularly resistance to cold-flow. In an accelerated cold-flow test on three grades of rubber compounds of various resistances to deformation, under compression (Fig. 6), the area of rubber exposed is many times greater, in proportion to rubber volume, than in the sleeve-type flexible coupling. The leveling of the

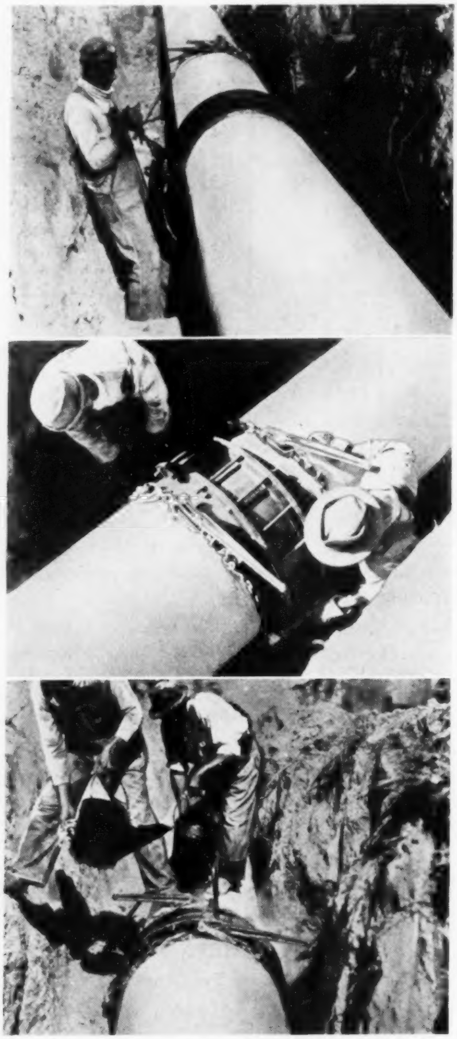
curves after a moderate initial pressure drop, demonstrates the ability of properly compounded rubber gaskets to maintain sealing pressure indefinitely.

Jointing Procedure

To assemble the coupling, a follower ring and a gasket are slipped over each plain-end pipe section about 6 in. from the end of the pipe. The middle ring is then placed over the end of the laid section of pipe until pipe stop or center bead on inside of middle ring is against the pipe end. The other pipe end is then stabbed into the middle ring until it reaches the pipe stop. The gaskets and followers are then slid up to and against the middle ring flares at all points. Bolts are then inserted, nuts run up finger-tight and final tightening performed with ratchet wrench. To insure uniform compression of the gaskets, diametrically opposite bolts are drawn up at the same time by two men working on opposite sides of the coupling, wrenching evenly and progressively.

Recommended practice for bolting-up large diameter couplings, is to position the nuts of the bolt so that each bolter will have his body approximately opposite the center of the coupling as he tightens bolts with his right hand (Fig. 7). This means that half of the nuts are positioned as though in two sets, each on opposite ends of the coupling for one-half of the circumference of the coupling.

All bolts are track-head, having an elliptical neck under the head which fits



Figs. 3–5. Process of Field Coating. Where Conditions Warrant, Couplings Are Field-Coated With a Thick Bituminous Material

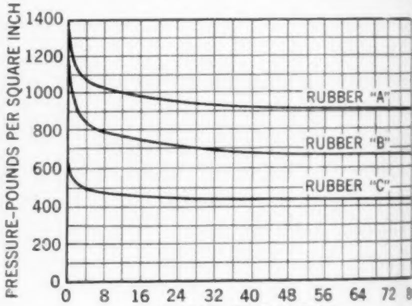


Fig. 6. Results of Accelerated Test to Determine the Effect of Time on Three Grades of Rubber Under Compression

to the elliptical holes of the follower ngs, thus preventing the bolts from rning while the nuts are being tightned. Time studies indicate that the

Fig. 7. Bolting-up Large Diameter Couplings

ssembling time from the placing of he first coupling part on the pipe, to he final tightening of the bolts, is pproximately as follows:

Size in.	Man-Minutes *
4	8
8	12
12	16
16	20
24	28
36	40
48	56

* Two men per joint.

An important cost saving factor is the practicability of using ordinary labor for jointing, with a minimum of skilled labor.

For large installations and for high pressure transmission line conditions, uniform adequate bolt torque may be assured by the use of torque-limiting ratchet wrenches. Depending upon the type of coupling, follower thickness, size of bolt and other factors, the torque will vary from 35-ft. lb. to 95-ft. lb. Specific recommendations for each individual project may be obtained from manufacturers.

The wrenching torque establishes gasket pressures against the pipe. In general, gasket pressure should be greater than pipeline pressure and the greater the ratio of gasket pressure to working pressure, the higher will be the factor of safety of the joint. Because of the wedge shape of the gasket and the method of confinement, only the small area of the gasket tip is subjected to the action of internal line pressure, so that virtually the entire bolt load is restricted to the initial compression on the packing medium.

Flexibility

Each joined pipe section within the mechanical coupling is in effect hinged on its individual flexible gasket, thus permitting each pipe to move independently in accordance with forces applied to it, and providing pressure-tightness under all conditions of pipe movement. When pipe movement takes place, the rubber gaskets flex and respond to such movements instantly, thus always maintaining an effective seal between pipe and coupling, under ordinary as well as under unusually severe operating conditions. Hence, the mechanical coupling remains tight under such conditions as vibration, shock, expansion, contraction and settlement.

Flexibility of the pipe joint is important; it is exceptionally desirable where local conditions impose constant

vibration, such as installations near railroads or subways, under streets carrying heavy traffic, and in localities where earth tremors are frequent.

Laying Pipe

In laying pipe with mechanical couplings up to at least 24-in. in size, it is feasible to make up substantially all of the joints on top of the bank at the side of the trench, or immediately over the trench, lowering the assembled pipeline into the trench in continuous progression as joints are coupled. This method of laying is often referred to as "snaking in" (Fig. 8). It is usual to use three trench spanners, placed about 40 to 50 ft. apart, or a few feet ahead of each successive coupling. Jointed pipe sections beyond the furthermost spanner rest on skids above the trench. When the trench is exceptionally deep, it is advisable to use one or more extra trench-spanners, thus retaining a uniform angle in lowering the pipe to the bottom of the trench. In any case a trench-spanner should be placed near each joint for pipe lowering.

It is desirable to lower the pipe evenly and at a moderate, uniform angle. This is accomplished under the directions of the Foreman, by simultaneous lowering of the suspended pipe sections at the three spanners. The first, or forward spanner sling is lowered slightly; the center sling dropped somewhat more than the first, and the third, or rearmost sling, lowered to the trench bottom. The rear spanner is then moved to the front and the process repeated (Fig. 9).

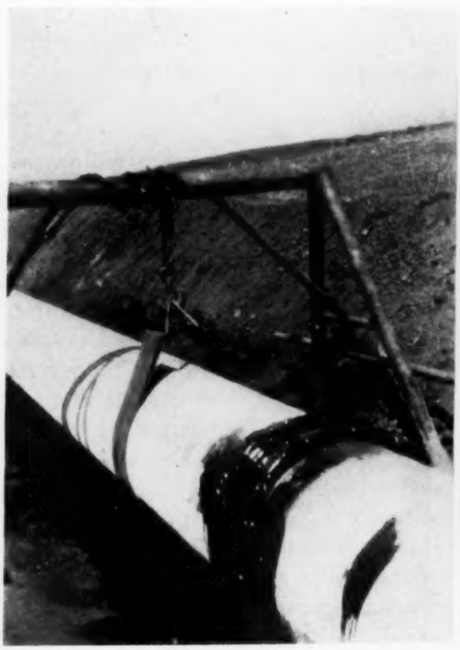


FIG. 8. Trench-Spanner 4½ ft. High, Constructed of Pipe, With Gear for Suspending and Lowering the Pipeline

FIG. 9. Preparing to Disconnect Rear Spanner From the Pipe and to Sling the Pipe Beyond the Two Spanners Ahead

The pipe laying method described fords not only reduction in laying osts, but also makes for effective inting under optimum conditions, and particularly advantageous in the case f a wet trench and in allowing a minimum width of trench excavation.

In laying larger sizes, it is customry to lower each length of pipe separately, and to couple in the trench, oint holes being dug at proper interals ahead of pipe laying. Flexibility f the joint permits adjustments to dhere to line and grade after jointing. n exposed trenches or under other onditions where pipe is subjected to ppreciable temperature changes, expansion and contraction is accommo-

Fig. 11. Leakage Test on 6-in. Mechanical Coupling Showed No Leakage at 450 psi. Hydrostatic Pressure When Deflected 10 deg. 30 min.

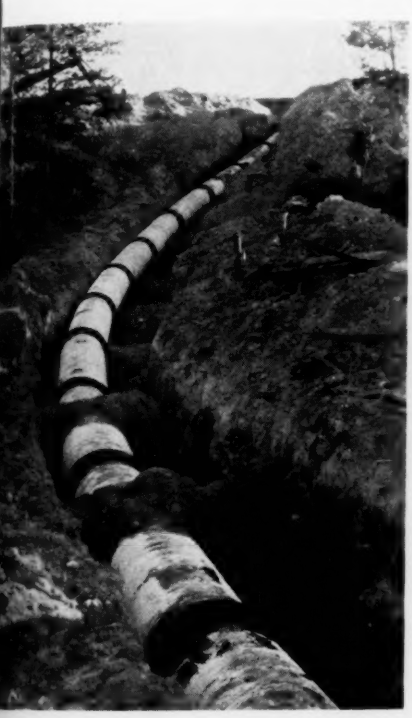


Fig. 10. Curves in the Pipeline Can Be Made With Standard Couplings and Straight Lengths of Pipe, by Deflecting the Pipe in the Couplings

dated without harmful stresses, due to freedom of longitudinal movement of the joined pipe.

Curves in the pipeline can be made with standard couplings and straight lengths of pipe by deflecting the pipe in the couplings (Fig. 10). This procedure often eliminates the use of specials for avoiding obstructions and for changing direction. Allowable laying deflections for mechanically-coupled joints are:

Size *In.*	*Max. Deflection* *Deg.*
$\frac{3}{8}$– 2	6
3–24	4
30–36	3
42–48	$2\frac{1}{2}$
54–60	2
66–72	$1\frac{1}{2}$
78–84	1

Expansion and Contraction

Pipelines along bridges are subjected to conditions which impose severe

stresses on joints, due both to expansion and contraction, and vibration. While the effects of temperature are well-known, possible ranges are indicated in the following:

Temperature Variation	Change in Length per 40-ft. length of Pipe	Per Mi.
Deg.	*Ft.*	*In.*
10	.0026	4⅛
20	.0052	8¼
50	.013	20⅝
100	.026	41$\frac{3}{16}$

Water-Tightness

While the problem of leakage is always of paramount importance, in instances it deserves particular consideration.

Mechanical couplings are practically leak-proof when installed with ordinary care. The tabulation below gives some available specific leakage allowances for various pipeline jobs, together with actual test leakage, which was almost invariably traceable to causes other than the mechanical joints themselves.

Leakage tests under deflection were made by Underwriters' Laboratories on 6-in. and 24-in. couplings. The 6-in. coupling (Fig. 11) showed no leakage at 450 psi. hydrostatic pressure when deflected 10°30′; the 24-in. coupling showed no leakage at 140 psi. hydrostatic pressure when deflected 10°40′ (Fig. 12).

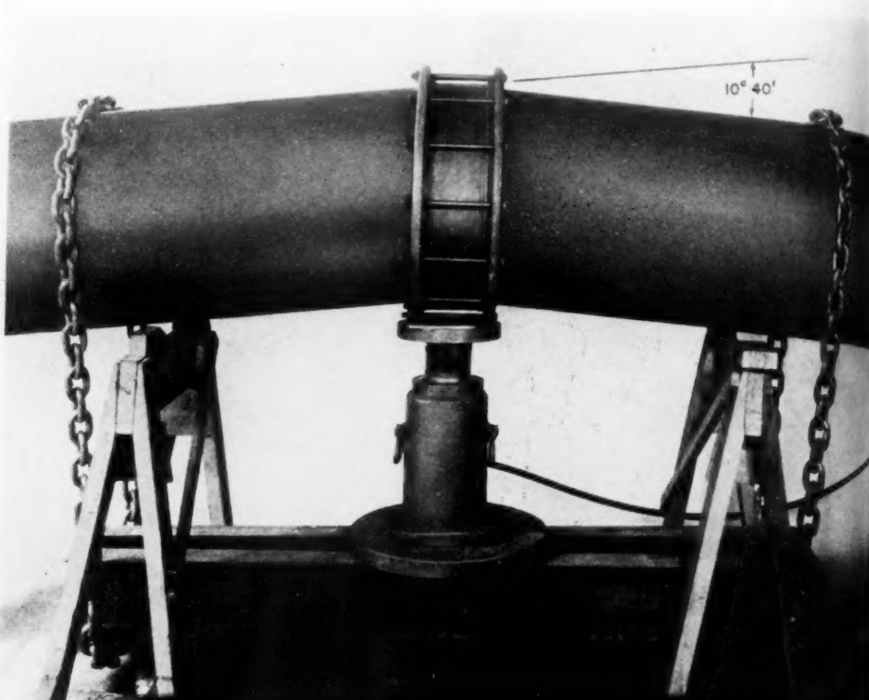


Fig. 12. 24-in. Coupling Showed No Leakage at 140 psi. Hydrostatic Pressure When Deflected 10 deg. 40 min.

TABLE 2

Location	Size	Material	Length	Test Pressure	Leakage in gpd. per in. mi.		
					Allow. Under Specs.	Actual by Test	Actual in % of Allow.
	in.		*ft.*	*psi.*			
Fort Wayne, Ind.	42	Steel	3,031	100	60	37.2	62
Kansas City, Mo.	42	Steel	2,600	108	—	17.0	—
Washington, D. C.	48	Steel	7,600	150	—	—	—
St. Louis, Mo.	60	Steel	46,895				
	54	Steel	11,015	115	125	2.74	2.18
	48	Steel	9,985				
Sheridan, Wyo.	16	Steel	18,625	400	—	0.625	—

The leakage on these installations was almost invariably traceable to causes other than the mechanical joints themselves.

Special Problems

There are various types and phases of pipeline construction which present special problems in jointing. For example, where unstable pipeline foundations are encountered, as in the case of sub-aqueous lines, or where special laying methods are required to be used as from barges and pontoons, such conditions tend to impose excessive longitudinal thrust on the joints, and in consequence, reinforced couplings are used.

In the reinforced joint (Fig. 13) four tie-bolts extend from lugs welded on the pipe to lugs welded on the middle ring of a standard coupling. Two of these tie-bolts, diametrically opposite each other, connect with one pipe section, while the other two tie-bolts, also diametrically opposite one another, but at a 90 deg. angle to the first pair, reach to the other pipe section. Flexibility is thus maintained in all places, as is a positive lock against extreme thrust at all times.

On unanchored bends, particularly when subjected to pulsating pressure such as water hammer, a joint harness (Fig. 14) is used. In this device "Crowfoot Lugs" are welded to the pipe at either side of the joint, and tie-bolts diametrically opposite, extend across the joint. This type of joint-lock is also adaptable to sub-aqueous work, especially on sizes above 16 in.

Metal Tips for Reduction of Electrical Resistance

A phase of steel pipeline construction often met is that of cathodic protection to prevent corrosion due to electrolysis. Under these conditions it is necessary to provide a joint with low electrical resistance. A similar requirement obtains where a low resistance joint is desired to facilitate thawing frozen water lines electrically. For these purposes mechanically coupled joints are provided with armored gaskets, or a copper bus-bar jumper bond may be used, if preferred.

Other Uses

Mechanical couplings have a variety of other uses in water works practice. It is good practice to place a mechanically coupled joint adjacent to the wall of a structure, on a pipeline entering the structure. The flexibility provided

Fig. 13. Reinforced Coupling for Unstable Pipeline Foundations

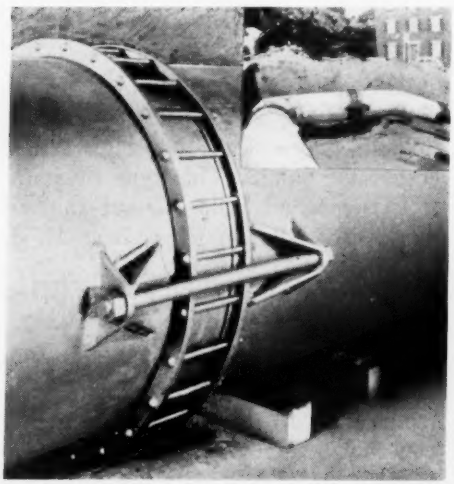


Fig. 14. On Unanchored Bends, Particularly When Subjected to Pulsating Pressure, a Joint Harness Is Used

will prevent undue stresses and possibly a failure of some character, due to uneven settlement of structure and pipeline. In pumping stations and filtration plants a flexible mechanically coupled joint has advantages over a lead-jointed sleeve when flanged piping is being installed, because in addition to providing a joint where length tolerances and lateral tolerances can be made up, the mechanical coupling also provides a joint which is easily installed and as easily dismantled for purposes of inspection, repairs, or future additions (Fig. 15).

It has been common practice to place a flexible coupling immediately adjacent to the discharge of pumps or other equipment, as a means of relieving flange stresses and providing additional flexibility in erection or dismantling, and particularly to take care of misalignments due to pump flanges or special castings failing to conform to the theoretical dimensions. When cou-

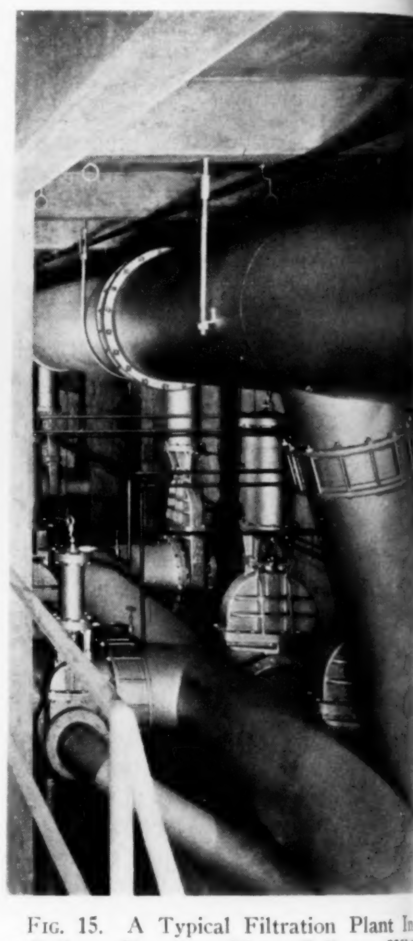


Fig. 15. A Typical Filtration Plant Installation Showing Pipe Gallery With Coupled Steel Pipe Connection

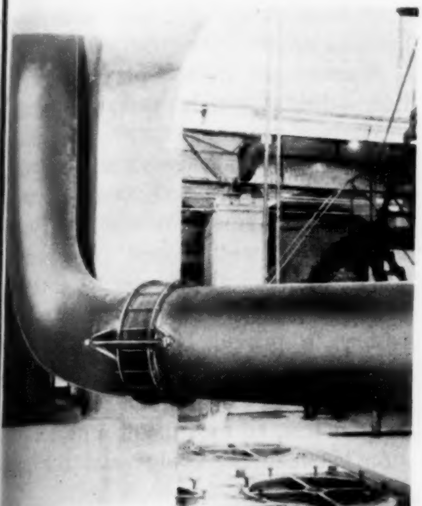


Fig. 16. Couplings Should Be Anchored or Harnessed Where There Is Substantial Line Pressure, Dead-Ends or Bends

plings are used under these conditions with substantial line pressure, dead ends or bends should be anchored or harnessed (Fig. 16). Couplings are also installed adjacent to motive equipment or to valves to protect them against damage from vibration, shock, expansion and contraction, as well as to insert or remove them easily from the line for any reason (Fig. 17).

When a coupled joint is between two flanged or calked joints, or on each side of a valve, it is necessary to specify that the center bead on the middle ring be removed, if little space is available for coupling installation, or if it is intended that the coupling be removable without disturbing adjacent joints. When space is limited the follower, with bolts inserted and gasket and middle ring with center bead removed, is slid over one piece of pipe which has to be of sufficient length to take all three pieces. The other follower and gasket on the adjacent piece of pipe are positioned, and then both pieces of pipe are bolted, calked, or set into position. The middle ring is then slid over to center on the joint and the coupling is bolted up.

Mechanically coupled joints, providing ease of dismantling, are also used for connection of removable sections to facilitate main cleaning; for temporary lines; for making repairs; for cutting in valves or fittings, and for closures (Fig. 18).

Another installation simplified by the use of mechanical couplings, is filter-surface wash piping (Fig. 19).

Mechanical joints have been adopted by the British Government as standard equipment for repairing main breaks due to bombings. Because of their convenience and flexibility, they are also utilized in making service connec-

Fig. 17. Procedure for Installing Coupling in Limited Space

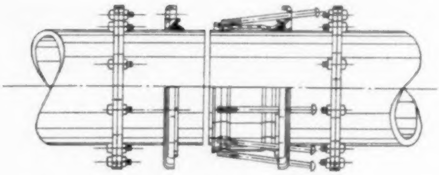


FIG. 18. View of Two 36-in. Sleeve-Type Couplings Without Middle Ring Center Stop on Either Coupling, Installed in Close Quarters. Used in Subway Construction.

tions, replacing the commonly used swing joint, or gooseneck. A boltless type of coupling employs the same packing principle as the bolted sleeve-type coupling. In the boltless coupling the gaskets are compressed by threaded nuts screwed on the middle ring; also this type of coupling is used on small drop-lines (Fig. 19), and is available in sizes up to 2 in.

A common type of pipeline construction advantageously utilizing flexible mechanical couplings, is that of bridge crossings. On bridges carrying considerable traffic, or subject to vibration from wind loads, flexibility of joints is essential, and is best provided by use of mechanically coupled joints. In bridge crossing construction it is necessary to provide for relief of pipe movement at points where there are expansion joints in the structure; also for differential expansion and contraction between the bridge and the pipeline.

Expansion-joint couplings are provided to absorb accumulated movements differential movements between

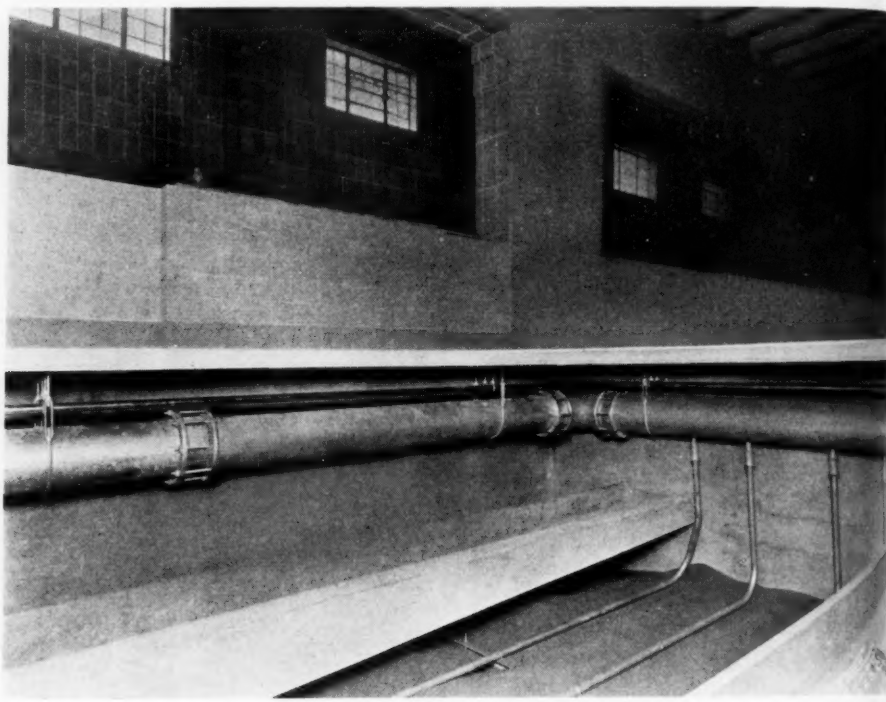


FIG. 19. Installation Simplified by the Use of Mechanical Couplings; Filter Surface Wash Piping

pipe and bridge being absorbed by regular mechanical couplings. While it is usually desirable to provide two supports per pipe length, to relieve the couplings of shear or bending stresses, the coupling can generally be safely used as a support for one end of a pipe length, where structural conditions do not permit more frequent support.

In conclusion, I wish to acknowledge with appreciation the generous assistance of the Dresser Manufacturing Company, who furnished much of the data and many of the illustrations for this paper.

Two New Developments in the Water Conditioning Field

By Samuel B. Applebaum

THE two new developments to be discussed in this paper are the "Spiractor" and "Demineralizing" processes of water treatment. The first of these is the latest improvement in the cold lime-soda process of water softening; the second is the latest development in the zeolite or ion exchange field and consists of the process of removing both the cations and anions from water by the use of organic zeolites or ion exchangers. Both developments have been described in previous papers (1–5). But additional data from actual operating plants have since been collected and are presented here.

The "Spiractor" process will be of interest to municipal and industrial plants planning ahead for the postwar period. The "Demineralizing" process is finding application in war-time industry, particularly in the chemical industries or wherever the equivalent of distilled water (water free from appreciable amounts of electrolytes) is desired at a comparatively low cost of production. This process will in the future also be of value in municipal treatment.

A paper presented on June 15, 1943 at the A.W.W.A. Cleveland Conference, by S. B. Applebaum, Vice Pres. The Permutit Company, New York, N.Y.

Spiractor Process

In the cold lime-soda process of water softening, discovered about 100 years ago, the cations Ca^{++} and Mg^{++} are precipitated as $CaCO_3$ and $Mg(OH)_2$, respectively, by the addition of lime and soda ash to water. The difficulties encountered in applying this process were mainly:

(a) Precipitation proceeded slowly at cold water temperatures, so that the precipitation chambers or tanks had to be constructed for many hours detention.

(b) Even with such large precipitation chambers, the precipitation was not complete. After-precipitation occurred and caused objectionable deposits in the filters and distribution pipe system.

(c) The precipitates formed, which settled out in the form of a sludge, were suspensions of fairly low concentration so that large volumes had to be disposed of either into nearby streams or, where such water-courses were unavailable, on to fields or into pits alongside. There the sludge was allowed to dry out in the sun and when dry, it had to be carted away for ultimate disposal for farm use or to fill in low places. Even where sludge disposal was possible by discharging into streams or rivers, troubles occurred because during dry periods of low

water flow, the sludge deposited in the bed of the stream and, after heavy rainfall, would be picked up and carried along in surges, which proved objectionable to water users downstream.

The history of the improvements in the cold lime-soda process discloses that they were the result of efforts to solve these three problems. For example, recarbonation was developed to improve the stability of the treated water, i.e., to prevent after-reactions. Then mechanical agitation and contact with suspended previously-formed sludge were found to hasten the precipitation, as well as to improve the stability. This led to the development of the sludge-contact type of equipment which permitted the reduction in the size of precipitation chambers or tanks from four to twelve hours down to under one hour detention, while producing a stable effluent of lower hardness. Attempts to solve the sludge disposal problem have thus far been made only in the laboratory and on a pilot plant scale. In the process developed the $CaCO_3$ part of the wet sludge is kept separate from the $Mg(OH)_2$; is evaporated to dryness; and then is reburned in kilns to produce CaO for reuse. If the process is ever adopted for actual plant use it will be probably confined to large plants.

Operators of the old-fashioned lime-soda plants have often observed the growth of the sand grains in the filters that followed the precipitation and settling units. This was due to the instability of the treated water and the after-deposits that took place in the filters. The growing filter granules often cemented together into larger masses (frequently called mudballs) which in some cases grew to the size of a watermelon. The operators also observed that a considerable softening of the water took place while the filter granules grew. It is of interest to point out in passing that, after the recarbonation process was developed to prevent such after growths or deposits, operators of lime-soda plants, e.g., Hoover and Montgomery (6) found that by using partial recarbonation, before filtration, the water was rendered less stable and caused the degree of softening by deposit on the filter granules, to be increased. Then post-carbonation was practiced after the filters (or of late hexa-meta-phosphate has been added) to accomplish complete stabilization and to protect the distribution piping system from after deposits. In other words, despite the troubles from uncontrolled growth of the filter layer, the additional softening accomplished thereby, persuaded some operators to suffer the troubles in order to gain the benefits.

The Spiractor is the most recent development to solve the same three main problems, an invention made by E. T. Zentner in Czechoslovakia about six years ago. Patents have been issued or are pending in various countries. A considerable number of large scale plants have been in successful operation in Central Europe, England and France. The Permutit Company acquired the rights to the U.S. patents and has devoted some time to the study and development of the equipment and its performance on different waters and under various operating conditions. Laboratory studies were first made, then pilot plants were installed in the field and finally a number of large scale installations were made, the result of which will be reported here. The first large scale Spiractor plant was installed in the U.S. in 1941 (Plant B in Table 1).

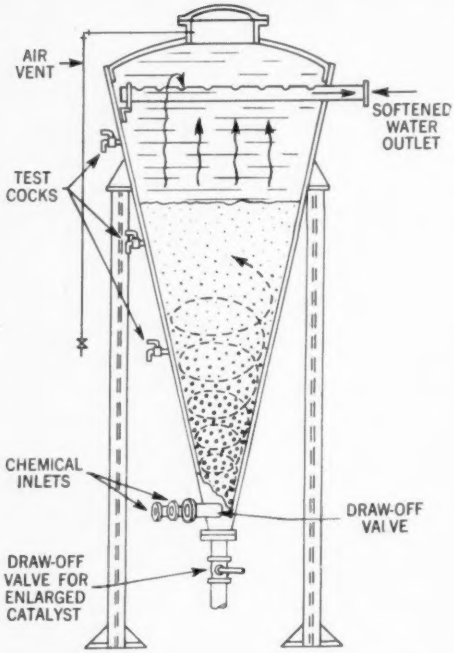


FIG. 1-a. Cross-sectional View of Permutit Spiractor Showing Flow

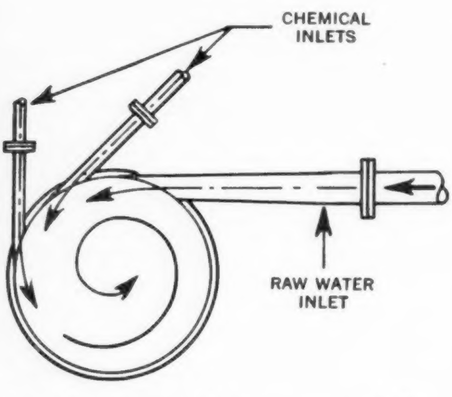


FIG. 1-b. Detail of Arrangement of Raw Water and Chemical Inlets

The lime and soda ash and the raw water both enter simultaneously and tangentially into the apex of a conical tank containing a catalyst, such as small limestone granules. The precipitates form immediately thereafter while the water is in contact with the catalyst to which the precipitates adhere as accretion (Fig. 1-a, 1-b). Due to the tangential entrance, the water takes a spiral course of flow, from which the name "Spiractor" was derived.

In the development of the Spiractor, the novel and great step forward was made of eliminating the sludge settling tank altogether as well as the sludge. Instead, the principle of the growth of the catalyst granules was transferred from a point late in the treatment process, that is, in the filters after the sludge settling tank, to a point at the very start of the process, immediately following the introduction of the chemicals into the water. That is the moment of greatest instability and it was discovered that the resultant precipitates formed, particularly $CaCO_3$, adhered firmly to the catalyst granules (Fig. 2). The word "Catalyst" has been used because of the intense acceleration in the water softening process accomplished, as well as by the fact that the catalyst granules act merely as nuclei or carriers on which the precipitates accumulate, but do not participate directly in the chemical reactions.

Efficiency of Spiractor

As an indication of its efficiency, the Spiractor attains in only 5 to 10 min., results which the older methods took one to four hours to accomplish. Also the wasted enlarged catalyst of a Spirator usually contains 90 to 95 per cent of solids and only 5 to 10 per cent of water compared to the usual strength of sludge of 1 to 5 per cent solids; 99 to 95 per cent water for the old-fashioned plant and 5 to 15 per cent solids;

95 to 85 per cent water for sludge-contact precipitators. Thus the precipitates are concentrated into a compact, almost dry form, which is granular, easy to handle and dispose of. For the first time, therefore, a real solution of the problem of sludge disposal has been attained. In fact, in the case of large plants, the grown catalyst can be crushed to the desired

FIG. 2. Enlarged Cross-Section of Catalyst After Accretion

smaller original size and used over again and the excess can in some cases be reburnt to make more CaO.

Spiractor Design Accomplishes Five Functions

The conical shape of the Spiractor and the upflow direction of the water through it serve five functions: First, they provide for high velocities at the apex which, together with the spiral motion, keep the catalyst bed suspended without the use of a mechanical agitator. By keeping the catalyst suspended and using upflow rather than downflow (as in filters), the trouble from cementation of the granules is avoided. Second, they provide for gradually decreasing velocities as the water rises upward through the unit, so that finally a velocity is reached low enough to leave the catalyst behind and allow the treated water to be separated from the catalyst as it emerges from the top. Third, by bringing the water and chemicals simultaneously into the apex of the conical container, no precipitates are allowed to form before contacting the catalyst. Fourth, the conical bottom facilitates the draining of the enlarged catalyst by gravity to waste. Fifth, the granule growth is controlled in that the bottom granules grow faster than the upper granules and hydraulic separation keeps the larger granules down. Then periodically, when the lower granules have grown too large for proper efficiency and suspension, they may be drained from the bottom of the Spiractor. Fresh fine catalyst is then periodically added through the top. Test cocks on the side of the Spiractor aid the operator in keeping the depth of the expanded catalyst bed up to the proper level. The top of the expanded layer is allowed to vary in level between the 2nd and 3rd test cock up from the bottom as shown in Fig. 1-a.

Control of Catalyst Granule Size and Depth of Bed

The grain diameter of fresh catalyst is about 0.1 to 0.5 mm. The granules are allowed to grow by accretion until they are too large to provide sufficient surface area in a given depth of bed to promote the desired efficiency of water softening reaction. The amount of fresh catalyst to be added at the top is determined by the permissible enlargement of the granules without

unfavorably influencing the chemical results. If the granules, before wasting, may be permitted to grow 50 times in grain volume as compared to the fresh catalyst granules, then the amount of fresh catalyst to be added will be 1/49 of the amount of precipitate formed on the original granules. If the permissible growth is 80 times, then the amount of fresh catalyst will be only 1/79 of the precipitate formed. When a Spiractor is first started, the partially enlarged catalyst, discharged from the bottom to keep the slurry from growing too deep, is saved for future reuse as makeup. After the granules have grown so large that they interfere with obtaining the best chemical results (lowest hardness and alkalinity), the enlarged granules are really wasted and the amount of fresh or fine catalyst added is determined by the relation of the original and enlarged granule volume as above explained. The frequency of discharge of enlarged catalyst is determined by the amount of hardness removed from the water, the size of the plant, number of hours in continuous operation, etc. But usually the frequency of wasting catalyst is once daily or once in several days. The catalyst withdrawal takes only a few minutes and is a simple operation. The cost of the catalyst is negligible, being usually less than a fraction of a cent per 1000 gal. For small plants, the wasted catalyst can be collected in buckets or wheelbarrows. For larger plants, it is discharged into collection waste pits alongside the unit, from which it is periodically shovelled out into trucks or cars. The handling of the fresh catalyst may be facilitated by using a hopper discharging into a hydraulic ejector which lifts the catalyst through a pipe into the top of the Spiractor.

Results From Actual Spiractor Plants

Table 1 gives the capacities and dimensions of some existing Spiractor plants in the U.S. and Table 2 the analyses of the raw and treated waters. Table 3 shows the stability of the effluent after various periods of standing. Plant C is of particular interest because the hardness and alkalinity of the effluent approach closely the solubility of $CaCO_3$ in cold water. Since a hardness (as $CaCO_3$) of 4 grains per gallon was desired rather than 2 gpg. undertreatment with lime is being practiced and the Spiractor operates just as efficiently. The well water used in Plant C is high in calcium hardness and low in magnesium hardness. Therefore, very little magnesium is precipitated. The calcium carbonate precipitated adheres almost completely to the catalyst and the effluent is exceptionally clear. Where considerable magnesium hardness is present in the raw water the effluent is not usually as clear.

Where well waters contain appreciable quantities of iron, aeration should precede treatment in the Spiractor. About half the iron present in Case C is removed by the Spiractor itself and the remainder is removed by the filters. Where iron and/or considerable magnesium hardness are present in the raw water it is advisable to design the filters that follow for not over 2 gpm. per sq.ft. operating rate and with proper surface wash.

In Plant B, the aerator effluent flowed to a pump suction tank before entering the Spiractor and in midwinter the temperature dropped below 50 deg F. when the well pump was shut down. When this happened the chemical results as well as the turbidity of the effluent suffered. This is not surpris-

TABLE 1

Capacities and Dimensions of Existing Spiractor Plants in the United States

	Capacity in Gpm.	Number and Size of Spiractor Units		Minutes Total Detention (Empty Tank)	Minutes Detention in Voids of Expanded Catalyst*
		Top Diam. ft.	*Height ft.*		
Plant A	100	1– 5.0	11.0	6.2	1.3
Plant B	70	1– 4.5	11.0	7.3	1.4
Plant C	2100	3–10.5	22.0	8.8	2.5
Plant D	1000	1–11.0	27.5	8.8	2.7

* Based on 50 per cent voids in expanded granule layer and with minimum allowable depth of granules.

TABLE 2

Chemical Analyses of Raw and Treated Waters

		Plant A		Plant B		Plant C			Plant D (Predicted)	
	Expressed as	Raw	Treated	Raw	Treated	Raw	Best	Under-treated	Raw	Treated
Total Hardness	ppm. as $CaCO_3$	320	72	271	76	150	34	63	354	50
Calcium Hardness	ppm. as $CaCO_3$	175	10	165	12	143	27	56	238	30
Magnesium Hardness	ppm. as $CaCO_3$	145	62	106	64	7	7	7	116	20
M.O. Alkalinity	ppm. as $CaCO_3$	330	70	382	184	150	34	63	268	80
Phenol. Alkalinity	ppm. as $CaCO_3$	0	36	0	92	0	9	8	0	65
Caustic Alkalinity	ppm. as $CaCO_3$	0	2	0	0	0	0	0	0	50
Free CO_2	ppm. as CO_2	15	0	10	0	12	0	0	8	0
Iron	ppm. as Fe	0.4	0.1	0.3	0.1	0.6	0.0	0.0	4.5	0.1
pH	—	7.6	10.4	7.8	10.5	7.2	10.3	9.4	7.8	11.0
Turbidity		5	0	5	0	5	5	5	30	0

Treated water analyses made on plant filter effluent.

ing, when it is considered that the rapidity of reactions decreases rapidly as temperature drops and that the Spiractor only provides 5 to 10 min. retention. To avoid this in the case of Plant B, the water level in the pump suction tank is reduced just before the well pump is stopped, so that on starting, the well water first fills the tank to raise the temperature to plus 50 deg. F.

Plants A, B, and D contain pressure Spiractors and thus repumping is avoided. Illustrated is a typical flow diagram of a pressure Spiractor installation (Fig. 3). Plant C contains three open top or gravity Spiractors (Fig. 4).

At first it was felt that the addition of a coagulant at the same time that the lime and soda ash are added would be helpful; but experimental study of the results with or without the addition of a coagulant at Plants A and B has shown that the coagulant is unnecessary. Plant C has no coagulant feed.

At first also it was felt that when

TABLE 3

Stability of Spiractor Effluent—Plant C

a) Spiractor effluent immediately after collection
b) Spiractor effluent 24 hr. after collection
c) Spiractor effluent 48 hr. after collection

	Sample		
	a)	b)	c)
Total Hardness (ppm. as $CaCO_3$)	41	40	41
M.O. Alkalinity (Alk A as $CaCO_3$)	41	41	41
Phenol. Alkalinity (Alk B as $CaCO_3$)	7	5	6
Caustic Alkalinity (Alk C as $CaCO_3$)	−27	−31	−29
Turbidity	5	5	5
pH by glass electrode	9.20	9.20	9.20

the Spiractor was shut down for long periods it would be necessary to recirculate for a while after shut down to avoid cementation of the grains. Later this was also found unnecessary.

Comparison of Various Limes

Some research work was carried out on the speed of reaction of various limes. It was found that not all limes act at the same speed and that some limes produce a clearer effluent than others. A simple test has been developed to act as a qualitative indicator of the more efficient limes. This test determines the turbidity when a given weight of lime is added to an amount of distilled water large enough to dissolve all the lime and avoid a supersaturated solution. The distilled water used is boiled to remove all the CO_2 present. The sample, after dissolving, is shaken and the turbidity read, and this turbidity is a measure of the insolubles present in the original lime. If the turbidity is too high, the lime should not be used with a Spiractor. In general, a pebble lime which has low insolubles by this test and which slakes rapidly gives the best results.

It has also been found that pebble lime freshly slaked at the Spiractor plant itself, reacts more rapidly than either pulverzied lime oxide or hydrated lime. Slaking tanks are being installed at Plants A and B. At Plant C, however, where the hardness removed is practically all calcium and where the temperature is higher (60

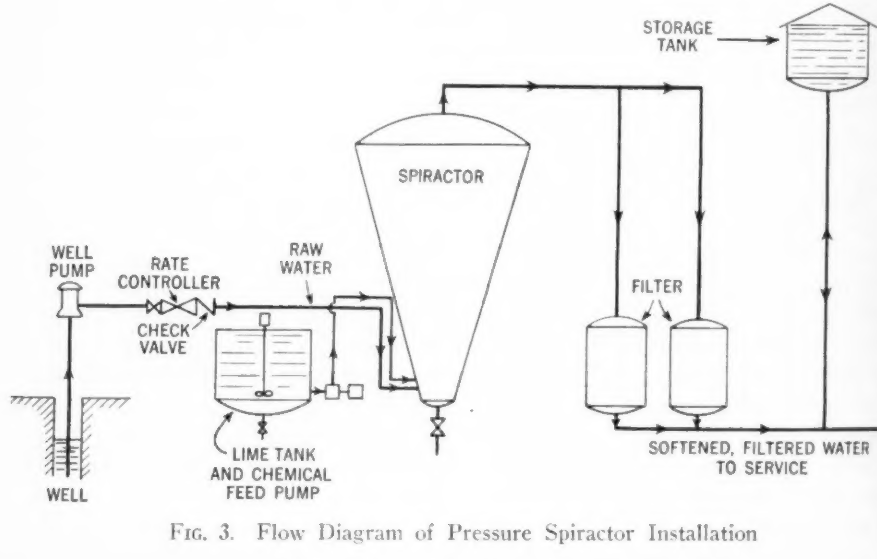


Fig. 3. Flow Diagram of Pressure Spiractor Installation

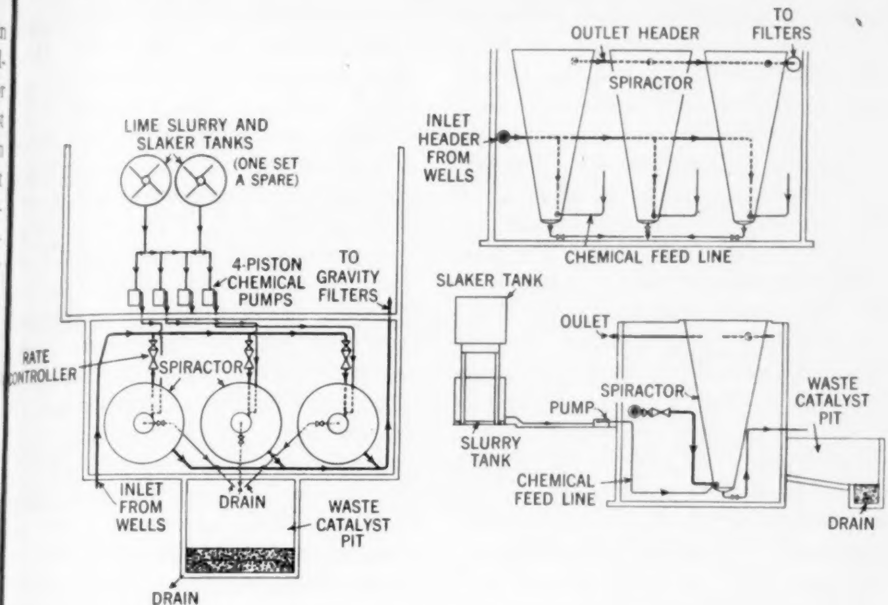


FIG. 4. Layout of 3-Mgd. Gravity Spiractor Plant

deg. F.), hydrated lime works as efficiently as the pebble lime.

Summary

From the experience to date, therefore, the type of water most effectively softened by the Spiractor appears to be a clear, high-calcium well water of over 50 deg. F. temperature. Spiractors should preferably be run at a constant rate, mainly to facilitate chemical feeding. If the well pump does not operate at a constant rate, a rate of flow controller should be installed ahead of each Spiractor unit to maintain such constant rates. The fields of application most suited to the Spiractor process are municipal plants, industrial cooling water treatment, paper mills and locomotive feed water.

Demineralization Process

The demineralizing process of removing both the cations as well as the anions present in water is the latest in the series of interesting developments in the zeolite or ion exchange field of water conditioning made during the last thirty years.

When the cation exchangers commonly called zeolites were first commercially introduced, the cations Ca^{++} and Mg^{++} in the water were removed by exchange for Na^{+} present in the zeolite. Regeneration of the zeolite was carried out with NaCl to restore the exhausted zeolite to the sodium zeolite form. The effluent was very completely softened, but contained sodium salts equivalent in amount to the total anions present in the raw water. When the hardness was principally bicarbonate, the effluent therefore contained sodium bicarbonate, which proved objectionable for some applications.

To overcome this objection, research work was started about ten years ago

to develop an organic cation exchanger which was capable not only of being regenerated by NaCl, but also by sulfuric or hydrochloric acid; and which, upon regeneration, would restore the zeolite into hydrogen zeolite. The successful product finally developed was the non-siliceous sulphonated-coal type of zeolite (Zeo-Karb). The first commercial hydrogen zeolite (Zeo-Karb H) plant was installed in 1936. Since its advent a great number of large scale hydrogen zeolite installations have been made (Fig. 5). By the end of 1942 the installed equipment had a total capacity exceeding 300,000,000 grains (as $CaCO_3$) per cycle.

The hydrogen zeolite removes the objectionable bicarbonate anion (HCO_3^-) by converting it into carbonic acid (H_2CO_3) which decomposes into free CO_2 and H_2O. The free CO_2 is removed by aeration in the efficient counterflow forced draft degasifier. However, the other anions, such as Cl^- and SO_4^{--} are not thus removed. The chlorides and sulfates present in the raw water are converted by the hydrogen zeolite to the corresponding acids HCl and H_2SO_4. These acids are then neutralized to form NaCl and Na_2SO_4 by adding alkalis, such as Na_2CO_3 or NaOH, or by blending with the effluent of sodium zeolite softeners which contains $NaHCO_3$. Thus the chlorides and sulfates in the original water are not removed but are converted to the corresponding sodium salts just as occurred with the original sodium zeolite softeners. Since sodium chloride and sodium sulfate also prove objectionable for many applications where the equivalent of distilled water is desired, research work has been concentrated on their removal. If only those acids created by the hydrogen zeolite could be absorbed, the job would be finished and demineralizing would become a successful reality.

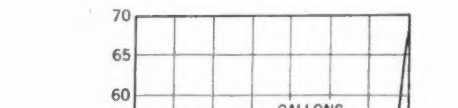


FIG. 5. Growth of Permutit Organic Cation Exchange Water Treatment During Past 7-Years

The British research workers, Adams and Holmes, reported in 1935 their development of one of the first acid absorbent materials that could be regenerated by alkalis and operate in repeated cycles. But it did not possess sufficient stability to stand up in service. Other research workers also developed acid absorbents or anion exchangers (as they are frequently called) but all of the early products suffered from the same defect. Our own laboratories over a period of years patiently synthesized and tested out a variety and large number (over 500) of organic products before they found one (De-Acidite) that would have high acid absorbent capacity as well as high stability. Unfortunately, there is no short term test for stability. The

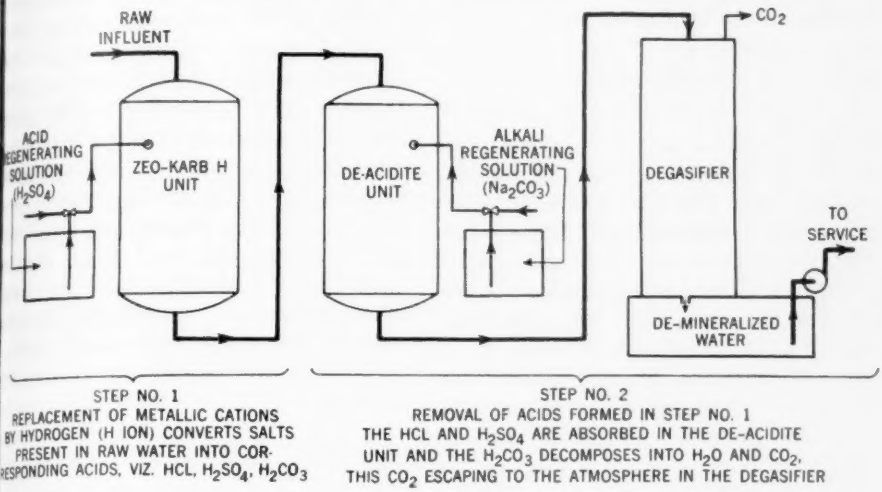


FIG. 6. Two Step Process for Demineralizing Water

material tested must be run and regenerated for hundreds of cycles on normal water before its suitability and stability can be verified. The use of abnormal waters of high salt content shortens the runs and therefore reduces the volume of water treated per cycle and is not representative.

De-Acidite is an aliphatic amine resin and has been in operation for several hundred cycles with only a small drop in capacity, imparting no color contamination to the treated water, and producing an effluent that remains constant in its low electrolyte. It is premature to predict that this anion exchanger will possess the stability and life of the older siliceous sodium zeolites or the later organic sulphonated coal type of zeolites, which have been operated for many years, day after day, for many thousands of cycles without loss of capacity, etc.

Principles of Demineralization

The demineralizing process is a two step series operation (Fig. 6). At the bottom of Fig. 6, the chemical action in each of these two steps is described. The reactions involved, using calcium sulfate as a typical salt, are:

$$CaSO_4 + H_2Z \rightleftharpoons CaZ + H_2SO_4 \qquad \text{(Step 1)}$$
$$H_2SO_4 + R_3N \rightleftharpoons R_3N \cdot H_2SO_4 \qquad \text{(Step 2)}$$

Where Z = cation exchanger
R_3N = anion exchanger

Bicarbonates are likewise transformed into carbonic acid in step No. 1, but since the anion exchanger only absorbs the strong acids, the carbonic acid passes through step No. 2 and is readily decomposed into water and free CO_2, so that it is removed when desired in the degasifier that follows the second step. Silica is not removed in this process and where silica is harmful, a silica removal plant must precede the demineralizing plant. Step No. 2 shows that the removal of the acid by the anion exchanger, De-Acidite, may be an absorption of the entire free acid molecule rather than an exchange reaction.

The reactions involved in the regeneration of the two units are:

$$CaZ + H_2SO_4 \rightleftharpoons H_2Z + CaSO_4 \quad \text{(step no. 1)}$$

$$R_3N \cdot H_2SO_4 + Na_2CO_3 \rightleftharpoons R_3N + Na_2SO_4 + H_2O + CO_2 \quad \text{(step no. 2)}$$

Either sulfuric acid or hydrochloric acid may be used in the regeneration of the Zeo-Karb in step No. 1. Usually sulfuric acid is used. Either caustic soda or soda ash or bicarbonate of soda can be used to regenerate the De-Acidite in step No. 2. Usually soda ash is used. The sulfates displaced in the regeneration in step No. 1 are rinsed to the sewer. The sodium sulfate and sodium chloride as well as the carbon dioxide displaced in the regeneration in step No. 2 are likewise rinsed to the sewer.

Distilled vs. Demineralized Water

It is often assumed that distilled water is entirely free from mineral salts. But due to the mechanic[al] carryover in evaporators and co[n]denser leakage, distilled water fr[e]quently contains appreciable quantiti[es] of such salts. Table 4 gives the anal[y]ses of samples of distilled water co[l]lected at a number of commercial in[s]tallations. The demineralizing proc[ess] produces an effluent the equal, an[d] often the superior of most distille[d] water supplies. The composition [of] the demineralized effluent depend[s] somewhat on the raw water analysis but on the average it may be stated a[s] follows:

Expressed as ppm. of $CaCO_3$	
Total hardness	0-2
Alkalinity to methyl orange	1-6
Chlorides	0-3
Sulfates	0-3
Free CO_2, ppm.	5-1
Color	Below

The cost of producing distilled wat[er]

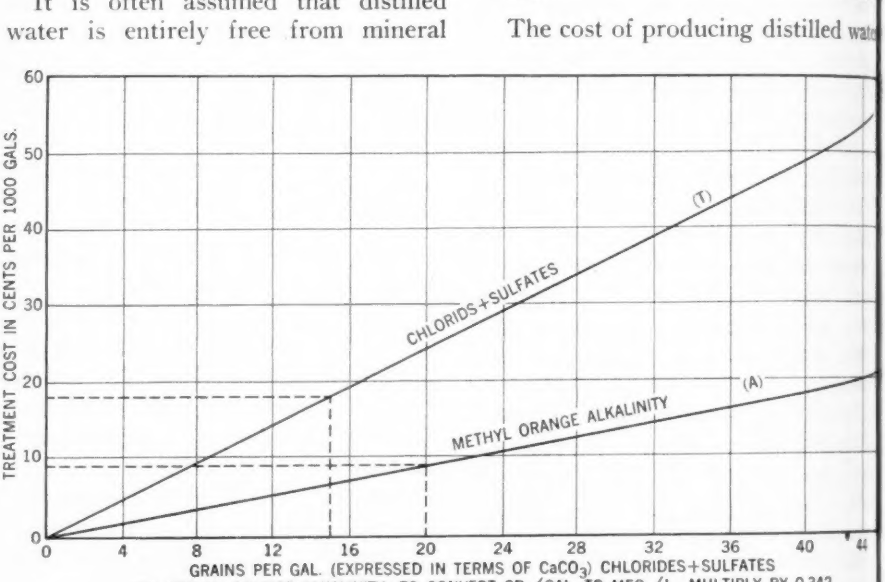


FIG. 7. Demineralizing Regeneration Costs are readily calculated from this curve. As a[n] example, consider a water containing 20 grains per gal. methyl orange alkalinity and 1[5] grains per gal. chlorides-sulfates (see dotted lines on graph). Reading up to Curve A from 20 grains and then left, the cost for removing the methyl orange alkalinity is 9.5¢ per 100[0] gal. Reading up to Curve T from 15 grains and then left, the cost for removing chlorides-sulfates is 19.5¢ per 1000 gal. The total chemical cost for remineralizing is 29.0¢ per 1000 gal.

depends on the number of evaporator effects used, the heat balance in the plant and other factors. The usual range of cost is from $2.00 to $8.00 per 1000 gal. with single effect evaporators and 60¢ to over $1.00 per 1000 gal. with quadruple effect evaporators.

The cost of demineralizing water depends mainly on the nature of the raw water. If the salts present are principally bicarbonate and the sulfate and chloride content is low, the size of the cation and anion exchanger plant is reduced and the operating cost is lower. In other words, it is more expensive to remove sulfates and chlorides than bicarbonates. A graphic method of determining the cost of regenerating a demineralization plant is based on using 66° Be sulfuric acid at 2¢ per lb. and soda ash at 2¢ per lb. (Fig. 7). For larger installations, where these chemicals may be purchased in carload lots, the cost may be reduced as much as 50 per cent below the figures given.

Bicarbonates are not only cheaper to remove in step No. 1 but since in step No. 2 the carbonic acid passes through without treatment, bicarbonates do not use up any capacity in step No. 2. That is why bicarbonates, expressed as methyl orange alkalinity in Fig. 7, show a much lower operating cost for their removal, as compared with chlorides plus sulfates (called theoretical mineral acidity, ThMA).

Efficiency of Cation Exchange in Step No. 1 Affects the Quality of Demineralized Water

Since the De-Acidite in step No. 2 only acts to remove or absorb acids, it is important that the effluent of the hydrogen zeolite unit in step No. 1 contains only acids. If the effluent of step No. 1 contains any salts in addi-

TABLE 4

Composition of Distilled Water Produced in Some Commercial Installations

(all figures are ppm. as $CaCO_3$)

Plant	A	B	C	D	E	F	G	H	I
Calcium and magnesium	0	6	10	10	0	0	0	15	1
Sodium *	19	3	8	5	11	12	9	6	2
Total Cations	19	9	18	15	11	12	9	21	3
Bicarbonate	13	9	18	15	5	5	4	12	2
Chloride	6	0	0	0	3	3	1	3	0
Sulfate	0	0	0	0	3	4	4	6	1
Total Anions	19	9	18	15	11	12	9	21	3

* By difference.

tion to acids, these salts would necessarily pass through step No. 2 and be present in the demineralized effluent. Therefore, to assure good quality of the final demineralized effluent, it is important to make certain of good quality of the hydrogen zeolite effluent.

The amount of salts present in the hydrogen zeolite effluent is a measure of the efficiency of the hydrogen zeolite exchanger. All of the bicarbonates are completely converted to carbonic acid. The salts present as sulfates and chlorides, which together are frequently called the Theoretical Mineral Acidity (ThMA) are not entirely converted to their respective acids. The actual amount of sulfuric and hydrochloric acid produced is frequently called the Free Mineral Acidity (FMA). The difference between the ThMA and FMA represents the amount of the salts present as chlorides and sulfates that have not been converted to their respective acids by the hydrogen zeolite in step No. 1. These unconverted salts in solution in the effluent of step No. 1 are of course dissociated into their respective cations and anions so that the influent of step No. 2 contains usually H^+ and Na^+ cations and HCO_3^-, Cl^- and SO_4^{--} anions and ap-

preciable undissociated H_2CO_3. In passing through step No. 2, practically all the H^+ cation is absorbed in the form of the strong acids HCl and H_2SO_4 leaving the Na^+ cation to balance the unabsorbed HCO_3^- anion. That is why the demineralized effluent usually shows the presence of (mainly) sodium bicarbonate alkalinity whenever step No. 1 is not completely efficient in converting chlorides and sulfates to their respective acids.

To increase the efficiency of step No. 1, that is to say, reduce the difference between ThMA and FMA, the use of greater regenerant dosages in step No. 1 is helpful. In a given case, for example, when the regenerant dosage was doubled, the metallic cations left in step No. 1 were reduced from 3 ppm. down to 0.6 ppm. and if the regenerant dosage was again doubled, the metallic cation content was reduced to 0.3 ppm. The metallic cation content in the above figures is expressed as $CaCO_3$.

De-Acidite Rinse Recycling

Not only must the cation and anion exchanger material be of suitable quality, but proper equipment design is essential to obtain optimum results. Accordingly, for economy in operating cost in large plants it is often desirable to recycle the De-Acidite rinse back to the influent of the hydrogen zeolite unit (Fig. 8). Fig. 8 shows a typical De-Acidite rinse curve and indicates the large volume of hydrogen zeolite effluent which must be used as rinse water to reduce the alkalinity down to 1 to 6 ppm. During the rinsing of the excess soda ash used in regeneration, the first part of the rinse is wasted to the sewer, but after the total dissolved solids content of the rinse drops to a value below the dissolved solids content of the raw water, it is recycled back to the inlet of the hydrogen zeolite unit (Fig. 9). During recycling the raw water inlet valve is closed and a pump is used to recycle the rinse effluent to the H_2Z inlet. A double sav-

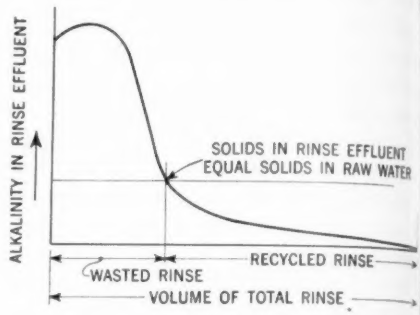


Fig. 8. De-Acidite Rinse Curve

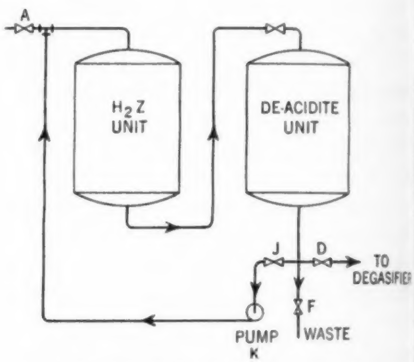


Fig. 9. De-Acidite Rinse Recycling Arrangement. (1) After Introducing Soda Ash for Regeneration, Rinse Through Valve F to Waste. (2) When Solids in Rinse Effluent Equal Solids in Raw Water, Close Valves F and A and Open J and Start Pump K. (3) Rinse Until Solids in Rinse Effluent Approach That of Distilled Water—Then Close Valve J and Pump K and Open Valves A and D.

ing is obtained. First, raw water is saved that would otherwise be wasted to the sewer and secondly, a smaller proportion of the cation and anion exchanger capacity is wasted in treating the rinse water, thereby leaving addi-

TABLE 5

Partial List of Demineralizing Installations

Company	Application	Date of Installation	Flow Rate Gpm.
A	Mirror silvering	1937	2.5
A-2a	Mirror silvering	1941	9–23
B	Cellulose acetate mfg.	1938	100
B-2	Plastics mfg.	1940	10
C	Chemicals mfg.	1938	1
C-2	Chemicals mfg.	1940	8
C-3	Chemicals mfg.	1940	8
D	Drug mfg.	1939	3
E	Drug mfg.	1939	10
E-2	Drug mfg.	1940	10
F	Cosmetics mfg.	1941	10
G	Cellulose derivative mfg.	1941	300
H	Pharmaceuticals	1941	5
I	Synthetic rubber mfg.	1941	55
J	Boiler Feed	1941	4
K	Explosives mfg.	1942	20
L	Cotton linters washing	1942	10
M	Synthetic Rubber	1943	400
M-2	Synthetic Rubber	1943	300
M-3	Synthetic Rubber	1943	200
N	Fine chemicals mfg.	1943	125
O	High Pressure Steam	1943	4
P	Chemical Processing	1943	40
P-2	Chemical Processing	1943	40

[a] Numbers indicate repeat installations for the same company.

tional capacity for useful runs. This is true because the cations in the recycled rinse keep falling off and approach zero. For example, in one case it was found that rinse recycling increased the capacity of the demineralizing plant over 15 per cent and reduced the waste raw water required for rinsing over 50 per cent.

Applications

The first commercial (Permutit) demineralization plant was installed about six years ago. Since then a large number of plants have been installed for a wide variety of application (table 5). Additional uses are storage batteries, alcohol deproofing, brewing, textile dye baths, photographic film preparation, ink manufacture, ceramics, carbonated beverages, plating baths, yeast manufacture, gelatin manufacture, pulp and paper manufacture, and many others.

Reference has frequently been made to the possibility of using the demineralization process for removing salt from sea water to take the place of stills now used for that purpose. However, due to the high amounts of chloride and sulfate present, the cost of operation would be much greater than the cost of distillation. Also the volume of rinse water required would be excessive. Waters that may be occasionally brackish can be economically treated by demineralizing. To reduce the operating cost in such cases, partial recycling and multiple demineralization have been found economical. Such special operating methods are not required on the general run of waters.

Special Operating Methods

In partial recycling, a portion of the demineralized water from the outlet of the anion exchanger is continuously circulated back to the raw influent to reduce the concentration of salts in the H_2Z influent. In a given case of a raw water containing about 700 ppm. of dissolved solids, a demineralized water containing 6 ppm. of dissolved solids was obtained and with partial recycling, the capacity of the plant was increased nearly 50 per cent.

Multiple demineralization is another possibility. After a certain volume of water has passed through the cation and anion exchangers once and accumulated in the storage tank, the raw water is shut off and the water in the storage tank is circulated back through the ion exchangers into a second storage tank. If during the second pass the quality of the effluent is still not low enough in dissolved solid content, the operation may be repeated until the desired quality is obtained. Multiple demineralization of highly saline waters not only permits obtaining a good quality of effluent, which would be un-

obtainable by single pass operation, but sharply decreases the chemical cost and increases the effective exchange capacity of the demineralizing units. In the case of a brackish water containing nearly 2800 ppm. of cations and anions respectively (expressed as $CaCO_3$) the yield was more than quadrupled by multiple demineralizing.

Future Applications

Research is proceeding in the application of demineralization for removing impurities from various liquids other than water. For example, in the manufacture of sugar, the removal of dissolved impurities from the mother liquor from which the sugar is crystallized, improves the yield of sugar and decreases the ash of the sugar produced. Similarly, gelatin solutions may be improved in quality by reducing the ash content. Many waste liquors discharging into streams and causing waste water problems contain valuable impurities which can be recovered by ion exchange methods.

Looking further into the future, application of silica removal plus demineralization will also undoubtedly be made for boiler feed water for high pressure boilers, where in the past only distilled water produced by evaporators had been considered suitable. Also as Goudey (7) predicted, demineralization may also find application in t removal of sodium sulfate or sodiu chloride in order to bring municip water within the limits of the U. Drinking Water Standard or below t damaging limit for home irrigation.

Acknowledgment is made of th original contributions of the Permut Research Department, headed by H L. Tiger, Vice President, and partic larly by M. E. Gilwood on the Spirac tor and by S. Sussman on De-Acidite

References

1. VAN PRAAG, JR., ALEX. High-Spe Water Softening Process Makes Municipal Debut. Eng. News-Rec. 12 92 (1942).
2. TIGER, HOWARD L. & GILWOOD, MARTIN Spiractor—The New Sludgeless C Lime-Soda Water Softener. Paper T J., **113**: 27 (1942).
3. MYERS, R. J. & EASTES, J. W. Sy thetic Resin Ion Exchangers in Wat Purification. Ind. Eng. Chem. 3 1212 (1941).
4. TIGER, HOWARD L. & SUSSMAN, SIDNE Demineralizing Solutions by a Tw Step Ion Exchange Process. Ind. En Chem. **35**: 186 (1943).
5. APPLEBAUM, S. B. Water Treati Equipment for War Industries. Pro Eng. Soc. of W. Pa. 3rd Ann. Con (Nov. 1942).
6. HOOVER, CHARLES P. Water Supply Treatment. National Lime Assn., Bu No. 211 (1941).
7. GOUDEY, R. F. Removal of Salts fro Water. A.W.W.A. **32**: 435 (1940).

Commission Controlled Water Department Operation—Ontario Practice

By William Storrie

THE Council of a municipal corporation which owns or operates a water works system or is about to establish such a system may pass a by-law with the assent of the municipal electors, to provide for entrusting the construction of the works and the control and management of same to a commission to be called "The Public Utilities Commission of the (naming the municipality)." It is to be noted that such a commission can only be established with the assent of the municipal electors and it can only be disbanded by the assent of the electors. Upon the repeal of a by-law establishing a commission, the control and management of the water works system is then vested in the municipal council and the commission ceases to exist.

A commission established under the Public Utilities Act of the Province of Ontario[1] consists of three or five members as may be provided by the by-laws, of whom the head of the municipal council is a member *ex officio*. All others have to be elected at the same time and place and in the same manner as the municipal council. Each member of the commission shall hold office for two years, half of the members retiring each year. The members of the

No member of the municipal council can be a member of the commission except the head of the council. Provision is set up in the Act for paying the commissioners as may be fixed by the municipal council. The general practice, however, is for the commissioners to serve without remuneration.

Powers of Commission

Once a commission has been formed, all the powers, rights, authorities and privileges under the public utilities Act are entrusted to the commission. The commission has full control over the construction of new works, the operation and maintenance of the system and everything relating to same is exercised by the commission and not by the municipal council—*with the exception* that the commission has no power to issue debentures or to borrow money for the construction of new works nor the power to borrow money from a bank for any purpose whatever. The right to issue debentures and to provide money required for capital expenditures is under the complete control of the municipal council. Any funds required by the commission for such capital expenditures must be paid to it by the treasurer of the municipal-

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[1] Revised Statutes on Ontario 1937, Chapter 286.

ity upon the certificate of the commission.

Annual Statement to Council

The commission is called upon on or before the first day of April in each year or upon such other day as the municipal council may direct, to furnish to the council a statement of affairs of the water works system as follows: (a) the number of customers supplied during the previous current year. (b) A balance sheet of assets and liabilities, including the value of the physical property, the amount of the sinking fund and the amount of current assets; also, the amount of outstanding debentures and of current liabilities. (c) A statement of revenue and expenditure, including the amount received from customers and the amount of other revenue, if any, also the amount expended for operation and maintenance, improvements and extensions, and for salaries and other office and management expenses, and the amount paid or set aside for interest, principal and sinking fund on the debentures.

The commission is also called upon to furnish sufficient information as from time to time may be required by the Council.

The accounts of the commission must be audited by the auditors of the municipality and the commission and its officers are called upon to furnish the auditors with such information and assistance as may be in their power to enable the audit to be made. On the other hand the commission may, if it so desires, appoint auditors to audit the accounts of the commission.

The revenue, after deducting disbursements, must be paid quarterly or oftener, if the council so directs, to the treasurer of the municipality, and shall be placed by the treasurer to the credit of the account of the public utility, and if not required for the purpose of the public utility shall form part of the general fund of the corporation. This section of the Act has been the cause of considerable friction between councils and commissions and will be referred to later on.

Acquiring Private Water Works Systems

Where a by-law of the council is passed with the assent of the electors entitled to vote on money by-laws declaring that it is expedient to acquire the works of a company for the purpose of supplying within such municipality any public utility, the municipality may take possession of the works of the company and all property used in connection therewith for the purposes of supplying such public utility, whether the works and property, or any of them, are within or without the municipality, and shall pay therefor at a valuation to be determined by arbitration under the Municipal Act.

Establishment of Municipal Water Works

The public utilities Act confers wide powers on a municipality whereby they may acquire, establish, maintain and operate a water works system and may acquire by purchase or otherwise and may enter on and expropriate land, waters and water privileges and the right to divert any lake, river, pond, spring or stream of water, within or without the municipality, as may be deemed necessary for water works purposes, or for protecting the water works or preserving the purity of the water supply.

No land, water or water privilege which is not situate within, or within

fifteen miles of, the municipality shall be expropriated under the power conferred by the Act and no water shall be taken from any lake or river except within, or within fifteen miles of, the municipality, or in either case so as to interfere with the water works system of any other municipal corporation or the supply of water therefor then in actual use.

The commission may construct and maintain, in and upon the land acquired by it, such reservoirs, water and other works, plant and machinery as may be requisite for the undertaking and may, by pipes or otherwise, convey the water thereto and therefrom, in, upon and through any land lying between the reservoirs and the water works and the lake, river, pond, spring or stream of water from which the water is procured or between them, or any of them, and the municipality.

The commission may, for such purposes, enter and pass upon and over such intermediate land, and may, if necessary, cut and dig up the same and lay pipes through it and in, upon, through, over and under the highways, lanes and other public communications within the municipality or within the distance limited by the Act and in, upon, through, over and under the land of any person within the municipality.

Power to Supply Water Outside of Municipality

The commission may supply water upon special terms and for such term of years as may be agreed on to owners or occupants of land beyond the limits of the municipality, and may exercise all other powers necessary for carrying out any agreement for that purpose. The commission has not the right where water is to be supplied to another municipality, to lay down pipes for that purpose within the municipality being supplied with water unless the municipal council of the municipality being supplied by water consents to same.

Surplus Funds

The Act states that, where a commission has a surplus, it must be paid over to the treasurer of the municipality and the municipal treasurer must retain same for the benefit of the water works system so long as there are any outstanding debentures or for any other water works purpose. This section of the Act has been the cause of considerable friction between the municipal councils and the commissions. The Act appears to be clear regarding this matter but the weakness lies in the fact that there is no authority to whom either the councils or the commissions can appeal in the event of a dispute arising between them. It would appear that authority to settle such matters should be vested in the Ontario Municipal Board or the Ontario Department of Municipal Affairs.

Where a commission has no outstanding debentures and where the surplus funds are not required for water works purposes the municipal council under the Act has the right to take such surplus funds and use same for the reduction of the general tax rate of the municipality. In Ontario cases exist where a commission has outstanding debentures and is even about to add to its debenture debts and such surplus funds have been used by the municipal council to reduce the tax rate.

Another weakness in the Act is that a commission may ask a municipal council to provide funds for a capital expenditure and apparently the munici-

pal council has the right to say whether such funds are necessary or not. Even if considered necessary there are cases where the council has refused to provide the necessary funds and that has been the cause of considerable friction.

The Act seems to be quite clear that where a commission requests a municipal council to provide funds for a capital expenditure the municipal council must provide such funds and has no other recourse open to it. The commission consists of elected representatives just the same as the municipal council. Their duty is to operate the water works system for the benefit and convenience of the citizens. If, in its judgment, a capital expenditure is necessary to carry out that function it surely should be compulsory for the municipality to provide the wherewithal for such purpose. Several instances, however, have occurred where the municipal council has refused to provide the necessary funds and in such cases the commission has had to abandon the contemplated expenditure. Even where surplus funds have been handed over to the municipal treasurer the council, in some instances, has refused to place such money at the disposal of the commission.

City of Belleville Case

A court decision has recently been given in litigation between the corporation of the city of Belleville and the public utilities commission of that City. This has to do with the authority of the commission to proceed with the construction of a reservoir estimated to cost $36,000.00, and for which the municipal council was asked to provide the necessary funds.

In Belleville, during recent years, the commission has handed over surplus funds to the council in excess of the cost of the reservoir and such funds have been used by the council in reducing the general tax rate.

The litigation involved the relationship between the council and the commission in so far as it applied to an interpretation of certain sections of the public utilities Act. The action was to restrain the commission from using any money in its hands or under its control, derived from the operation of the water works system of the city, until such time as the council provided money for said work and further for an order directing the commission to hand over to the council all monies or securities for money derived from the water works system and not needed for its operation and maintenance.

The decision of the court clearly indicates that under Section 44 of the Act the commission can insist that all monies paid to the council must be set up in a special account and placed to the credit of the commission. Again the court decision states that when the commission was formed all the powers conferred on the municipal council under the Act were transferred to the commission as to management, maintenance, operation, improvement and extension of the water works system with the sole exception that the commission cannot issue debentures for capital expenditures or create a debt of any description. The court decision, however, states that the commission cannot proceed with the construction of the reservoir without the authority of the municipal council and, since the decision was rendered early this year (1943), the municipal council has refused to provide the necessary funds.

From the point of view of administering the water works system, the Act as it stands, coupled with this recent court decision, creates a situation that

is far from satisfactory. The commission has full power to administer, maintain and extend the water works system, yet it has not complete control over the revenues derived from same. The Act should be amended to such an extent that where a commission decides to embark on a capital expenditure the municipal council should automatically be compelled to furnish the necessary funds. The court decision is to the effect that the commission cannot proceed with the construction of this reservoir unless and until it has funds in the hands of the municipal treasurer available for such work or the undertaking of the municipal council to provide such funds.

The last clause of the judgment shows the weakness in the whole situation when it states that no decision is given which determines where or when funds in the hands of the municipal treasurer are available for the construction of the reservoir. The Act calls upon the commission to hand over surplus funds to the municipal treasurer from time to time but there is no provision set up in the Act as to how the commission can get the money returned from the municipal treasurer without the consent of the council.

Summary

The public utilities act on the whole has worked out satisfactorily in Ontario with the exception of problems relating to the power of the commission to utilize surplus funds for capital expenditures and to compel the council to provide capital. Whilst many of the municipalities in Ontario during the years of depression went into default, there is no case where a water works system controlled by a commission was not able to meet all its obligations. The right to set up a water rate structure is entirely in the hands of the commission and is not subject to any control from the municipal council. The right to create a surplus in the operation of the water works system is entirely in the hands of the commission. It would appear to be good business to create a reasonable surplus and utilize it for what might be looked upon as minor capital expenditures in order to keep the capital debt at as low a figure as possible. The commission on the other hand can reduce the water rates and thus avoid the creation of a surplus. In a few instances water has been given without any charge to the citizens for a period of two or three months in each year.

If the relationship between a municipal council and a commission is to be kept along harmonious lines then some change is necessary in the Act in order to overcome the present unsatisfactory state of affairs. It is anticipated that at the next session of the Ontario Legislature, the necessary amendments to the Act will be put through to remedy the situation.

In conclusion it may be noted that some of the commissioners have long years of continuous service as members of their commission. There are twelve commissioners in Ontario who have had continuous service of from 25 to 44 yr., or an average of 30 yr. service for each of the twelve commissioners.

Commission Controlled Waterworks Operation in Wisconsin

By L. A. Smith

THERE are many factors which affect successful municipal water works operation. It is quite obvious that there should be continuity of service, not only in the case of the superintendent or manager, but also among the employees, and that there should be no political interference in the operation of publicly owned utilities. It is important, also, that the use of the funds of the utility should be under the direct control of the utility management. It is equally desirable that rates be fixed by a regulatory body so that high utility rates are not put into effect to absorb part of the tax load. Civil Service and the merit system of promotion are extremely desirable for successful management, and a pension system for water works employees helps to decrease turnover and to increase the effectiveness of employed personnel. All of these policies are legally available to water utilities in Wisconsin.

Management

The statutes of Wisconsin provide that in *cities* owning a public utility, the Common Council *shall* provide for a non-partisan management by creating a utility board. These utility boards may be composed of three, five or seven commissioners. The law further provides that in *towns* owning a public utility, similar water commissions *may* be set up. These water commissions, "shall take entire charge and management of such utility, appoint a manager and fix his compensation and supervise the operation of the utility under the general control and supervision of the Common Council." Prior to 1907, the law provided that the Board of Public Works might act as a water commission, or that the utility might be administered through the agency of the common council. Some utilities are still operated through the board of public works or common council committee under a grandfather clause in the statutes which permits them to operate as they had prior to the passage of this law, if they prefer.

Local and State Situation

It is particularly appropriate that I be asked to discuss the matter of water utility commissions because the city of Madison had the first Board of Water Commissioners in Wisconsin. The local plant was built in 1881 through the agency of a committee of the common council, which operated it for two years. In 1883, the Common Council requested the legislature to grant permission to place the manage-

A paper presented on June 16, 1943, at the Cleveland Conference by L. A. Smith, Supt. of Water Dept., Madison, Wis.

ment of the water utility under a Board of Water Commissioners. By special action of the legislature, this was added to the special charter of the city of Madison. The original Board of Water Commissioners in Madison consisted of five members—three citizen members elected by the common council, the mayor of the city, exofficio, and one alderman elected by the common council. The terms of citizen members are for three years and one is elected each year. This tends to provide a continuing policy because there is no opportunity for one council to change the majority of the Board. This form of management has continued in Madison for nearly 60 yr. and new members have only been elected to the Commission by the common council to replace former members who have died or who have resigned because of inability to serve. One member of our present Board has served continuously since 1911 and terms of office of twenty years have not been uncommon. In 27 cities in Wisconsin above 10,000 in population, eighteen are operated by a water commission, four by a city manager, two are privately owned, two are operated by the board of public works and one by a council committee. The law provides that in the city manager form of government, the city manager shall assume the duties ordinarily assumed by the board of water commissioners.

Public Service Commission

I would like to call attention to several other statutory provisions affecting water utility operation in Wisconsin which affect management very definitely. Publicly-owned utilities come under the regulation of the Wisconsin Public Service Commission. They are entitled to the same rate of return as privately-owned utilities enjoy. The Public Service Commission is made the judge of the adequacy of the service being rendered by all public utilities and requires that all utilities, whether publicly or privately owned, shall keep a set of accounts according to the Public Service Commission classification of accounts and make an annual report upon the forms prescribed.

Since its establishment in 1907, the Public Service Commission of Wisconsin has insisted that each utility earn a sufficient revenue, not only to pay all operating and maintenance expenses, but also to provide an adequate amount for depreciation and for the payment of local taxes to the municipality. It has also insisted that each utility keep its funds separate from those of the municipality.

The Commission has always held that no free water be furnished to any person or organization. In Madison, which is fairly typical in this respect, all of the churches, hospitals, schools, and public buildings, whether owned by the federal government, state, county, or city are metered and the water paid for at the regular meter rates. Even the public bubbling fountains in Madison are individually metered.

Water Funds

The statutes also provide that the income of a public utility owned by a municipality shall first be used to meet operation, maintenance, depreciation, interest, sinking fund requirements, local or school tax equivalents, additions and improvements, and other necessary disbursements or indebtedness. Income in excess of these requirements may be used to purchase or hold interest bearing bonds, issued

for the acquisition of the utility; or bonds issued by the United States or any municipal corporation of this state; or insurance upon the life of an officer or manager of such utility; or may be paid into the general fund.

Another important provision is that unpaid water bills are a lien on the real estate to which the water is furnished and "all sums that have accrued during the preceding year and are not paid by the first of November of any year are to be reported to the treasurer by the city clerk who shall insert the same in the tax roll as a delinquent tax against the property." Water receipts in Madison amounted to about $400,000.00 last year and only $448.87 was placed on the tax roll, so that 99.9% of all of the water bills were paid for in cash, and only approximately .1 of 1 per cent were delinquent.

Miscellaneous Statute Provisions

In 1912 a statute was added providing that water mains may be installed on a benefit basis. The particular law in Wisconsin provides that property owners may be assessed half of the cost of a 6-in. main installed in front of their property and court decisions have, in general, limited these assessments to $1 per front ft. against each side, upon the assumption that the average 6-in. main costs approximately $2 per ft. The city of Madison adopted this provision in 1913 and since that date has installed nearly 100 mi. of mains at a total cost of over $1,000,000.00. The benefit assessments have been approximately 30 per cent and the water department share of the cost about 70 per cent. The reason for the low benefit assessments is that the new mains installed averaged considerably larger than 6-in. in diameter and feeder mains, which were installed on streets having smaller service mains, cannot be assessed because technically no additional benefits accrue to the property abutting such feeder mains.

There are a few other provisions which might be mentioned in passing. The law provides that a municipally-owned utility may serve persons or places outside the corporate limits and may interconnect with another utility for the purpose of providing better utility service in any area. Another provision is that the actual construction work of a public utility shall be under the immediate supervision of the Board of Public Works or corresponding authority, although in the majority of cases the water utility provides the engineering service. This is under the theory that the Board of Water Commissioners is the operating unit.

Control of Council

There has been considerable discussion as to the meaning of the statute which provides that the Board of Water Commissioners shall supervise the operation of the utility under the *general control* and *supervision* of the Common Council. In some cities, the Board of Water Commissioners exercises almost complete control, having its own employment program and its own personnel regulations, as well as setting up and administering its own budget in every detail. I think that both the city as a whole and the water utility can benefit by joint action. For instance, in Madison the water department accepts the vendors selected by the city in the purchase of many supplies used by the water department in common with other city departments. The purchase of gasoline and lubricating oil is a good example because by uniting the purchasing power both the city and the water utility benefit by

the increased volume of supplies purchased. I think that all city employees, including utility employees, should work as a unit for the best interests of the city they serve and for this reason there should be uniform personnel control in all municipal departments. I refer specifically to the practice of hiring under civil service and to provisions for sick leave, vacations and other items of that sort. Co-operation in these matters is extremely desirable because, in any except the larger cities, a separate civil service commission and separate purchasing department for the water utility are uneconomical. The water department of the city of Madison submits its annual budget to the Common Council as a matter of record, but the Council has never exercised any supervision over it nor has it ever made any changes in it.

I have been trying to think of some facts which I can present to indicate to you whether or not water utility operation under a board of water commissioners, as provided in Wisconsin, is successful. I sent out a questionnaire to some 30 of the larger cities of the nation and received replies from nearly all of them. Without a single exception, those cities operating water utilities under a board of water commissioners felt that this was the best type of management, and in the majority of cases, where other agencies were operating the utility the managers indicated that they thought a board of water commissioners would be superior to the type of management which they have.

Continuity of Office

The matter of continuity of office of the superintendent or manager is important and I have checked over the last six changes which have occurred in the 30 largest cities. Incidentally, I have had to go back over ten years to get six changes in superintendents in this group. In four cases, the present superintendents succeeded men who had died in actual service. In one case, the present superintendent succeeded a man who had to resign because of ill health and the sixth case concerns Mr. H. H. Brown who was elected superintendent of the water department in Milwaukee to succeed Mr. Henry Bohman who has retired on a pension after serving the city of Milwaukee for nearly 50 yr. From these facts, it is apparent that new superintendents have, in general, been appointed only because of the inability of their predecessors to continue in service.

Physical and Financial Data

There is no adequate measure which can be used as a criterion to determine whether or not a water utility is successful. From the questionnaires received, I have analyzed the twelve largest cities in Wisconsin and have some interesting statistics with reference to their water utilities. The total population served by the utilities in these cities is in excess of 1,000,000, or approximately one-third of the population of Wisconsin. There are over 200,000 customers, which indicates that there is one customer for every five persons in the area served. The property and plant value is in excess of $50,000,000.00, or about $50 per capita. All of these utilities pay taxes to the city at the local tax rate, the amount involved last year being $1,125,000.00, or about $1.15 per capita. The net profit, after operating expenses, maintenance, taxes and depreciation are deducted is $1,450,000.00, or $1.45 per capita. The aver-

age rate of return is approximately 5 per cent on the money invested by the utility itself, as differentiated from the amount paid by consumers in the way of main assessments, cost of water connections and meters, and also any contribution of the federal government through WPA or PWA.

One of the best measures of the efficiency of a water utility is the percentage of *water-accounted-for*. In the cities answering the questionnaire, taken as an entire group, 82.9 per cent of all water leaving the pumping stations passes through permanently set meters. About half of the balance is used directly through hydrants in flushing streets, sewers, in public construction and fire department uses. The other half is unaccounted for, which means that in general the *unaccounted-for-water* is less than 10 per cent, which is an excellent record.

Selective Service

A few weeks ago, I made a survey to ascertain the effect of selective service on water works personnel in Wisconsin. In the 25 largest cities selected, involving a total population of 1,250,000, there were, on January 1, 1941, 910 water utility employees; i.e., approximately one for every 1400 in population. By May 7, this year, this had been reduced to 876, a reduction of about 4 per cent. This reduction took place in the face of large increases in the water being furnished in many of the cities. In Madison, for instance, the increase is over 20 per cent. Fifty-six water works employees were drafted, 20 have enlisted and five are serving in an engineering capacity with the Army. Only 20 deferments have been applied for, with favorable action by local draft boards in most cases. It is expected that an additional 45 will be drafted or enlist b[y] for the end of the year.

In the questionnaire which I se[nt] out, I asked what expedients we[re] being taken to compensate for the lo[ss] of these employees and I find that, [in] general, this problem has been a[t]tacked from four angles: (1) In som[e] cases, former employees who ha[d] reached the retirement age were aga[in] working, some on a part-time bas[is]; (2) some of the positions were fill[ed] by new employees over the draft age; (3) almost invariably I find th[at] women are being engaged to do wo[rk] formerly done by men. (In fact, M[r.] George Corine, Manager of the wat[er] utility at Superior, is using women [as] meter readers on a trial basis.) (4) a[n]other wartime expedient adopted b[y] many utilities to conserve man pow[er] and avoid repeat calls in reading meter[s] is the practice of leaving postal cards addressed to the utility, with consum[ers] who were not at home, asking the[ir] cooperation in reading their ow[n] meters. These cards bear a facsimil[e] of the consumer's meter dial and he [is] requested to draw lines to indicate th[e] location of the hands as they appear [on] the dial and drop the card in the mai[l]. This scheme is in effect in Madiso[n] and we found that in a test sampl[e] 88 per cent of the consumers re[s]ponded. Of the returns received, ov[er] 93 per cent sent in correct reading[s] and only 7 per cent sent in reading[s] which were obviously inaccurate, [in] many cases due to reading gas or elec[tric] meters. I am certain that th[is] scheme is going to work out satisfac[]torily and I recommend it for trial.

Conclusions

I am a whole-hearted advocate of a board of water commissioners, as se[t] up by the statutes in Wisconsin: (1

feel that there are, in every community, civic-minded individuals who ill take a keen interest in the water tility and give considerable time and ergy to its affairs. If a department administered by a committee of the mmon council, the management of e department is likely to suffer because it is only one of the items for hich the members of the committee is sponsible, (2) the type of commission which has developed in Wisconsin, nder this statute, has, with almost no xceptions, provided a uniform and ntinuous management policy which does not change with political administrations, (3) such a commission can be of tremendous value if some of the citizen members have a technical background, enabling them to be of real value in operating procedure, (4) and most important of all, a commission of this kind can and will interest itself in long-range programs of development, whereas in some other types of management, additions and improvements to the plant are made only when the supply is so adversely affected as to make such additions absolutely necessary.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene* (*British*); *C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research* (*British*); *I.M.—Institute of Metals* (*British*).

WARTIME WATER WORKS PROBLEMS

Water for War. V. C. Jones. The Driller **17:** 9: 6 (Sept. '43). Well water moving into realm of scarce materials. WPB limitation order in prepn. decreeing no well constr. until Office of War Utilities studies effect on other wells and passes on exact location. At present, only N.M. and Ariz. having surface-water troubles but ground-water supply shortage gen. Estd. war production water use 30% above normal. As part of govt. program to conserve nation's water supply, surveying water utilities to det. deficiencies in systems which would result from extended drought conditions and to est. materials required to maint. service. While present supplies ample, prolonged drought would slow war effort more than anything else, because 1 ton ingot steel requires 75 to 80 tons of water; steel before fabrication, 175 tons; 1 gal. gasoline, 70 to 100 gal.; 1 gal. alc., 236 gal.; testing 1 airplane, 125,000–150,000 gal.; and at new synthetic rubber plant, 120,000 gpm. Since Pearl Harbor, water demands exceeded all predictions and placed phenomenal strain on many of 13,500 water utilities serving 85 million people. About 9000 munic. owned. More than 500 bear major portion of war burden. Recent compilation of deficiencies in supply, pumping, treatment, distr. and storage facilities showed serious status in one or more categories in 272 cities and potential deficiencies in 119. Approx. ⅓ in supply, with distr. and treatment next in order. Newport News, San Diego, Detroit, Cleveland and Buffalo received hard impacts of war in order of severity. N.J. avoided shortage by inter-connecting major reservoirs. Louisville, Ky., and Joilet, Ill., suffered depletion by nearby indus. wells. Coastal regions troubled with salt water replacing fresh on drawdown as in Mobile, Galveston, Corpus Christi, Texas City and Baton Rouge. Mill Creek Valley near Cincinnati having same trouble. Well-water deficiencies from war production affect S. Atlantic, E. Northcentral, and Pacific Coast regions. Distr. deficiencies particularly bad in Pacific coast, S. Atlantic, New England, W. Southcentral and E. Northcentral areas. WPB urges water utilities to defer major extensions and betterments but not to delay maint. Wholehearted co-op. in nation-wide conservation program, much like Philadelphia staged last yr. (*see* Jour. A.W.W.A., **35:** 17 ('43)), would save 25% of entire supply without hardship to anyone. In view of war production approach to top war demands situation serious and no room for complacency.—*Ralph E. Noble.*

World Sanitation. Anon. Calif. Health **1:** 30: 29 (Sept. 15, '43). Shortly after World War, George C. Whipple discussed world-wide sanitation with remarkable insight. In spite of wars, commercial struggles, political boundaries, race and language differences, religious and social customs, desire to conquer disease bound to draw human race together. Latter learning that communicable disease largely elimd. by co-op., gives basis for hopeful view of world-wide sanitation. Enlarges upon following factors contributing to unsettled conditions: (1) nature of indus. developments; (2) congestion of cities; and (3) increased rapidity of disease transmission

As corollary, world sanitation needs 3-channel direction to safeguard (1) and (2) and prevent (3) above. Plead for promotion of indus. sanitation in particular, better disposal of human excreta, water purif., better recording of vital statistics universally, uniform plan for san. surveys and gen. pub. health promotion. Recommended establishing one place in world where all important and reliable statistics found and internatl. vital statistics popularized. San. surveys have 3 functions: (1) learn to collect information; (2) teach and inform people of own san. condition, spreading idea good health possible and, to strong nation, essential; and (3) utilize collected facts as basis for action, means to discover san. shortcomings and guide in appropriating for pub. health projects.—*Ralph E. Noble.*

Postwar Prospects in the Water and Sewage Treatment Fields. A. E. Berry. Eng. Cont. Rec. **56:** 29: 46 (July 21, '43). Discussion of importance of planning for postwar construction and review of prospects in Ont. Dept. of Health ests. that expenditures for new projects alone should approach **$40,000,000,** 50–65% being for direct labor. Radical departures from existing methods less likely than steady progress in refinement of present procedures. Not sufficient that water supplied be merely safe for domestic use—must be of good quality in all respects. Considerable no. of water supplies in Ont. require filtration. Taste control and softening also fertile fields. Greater restrictions on stream poln. should lead to expansion of sewage treatment facilities.—*R. E. Thompson.*

Health of the United States at War. Anon. Pub. Health Rpts. **58:** 1281 (Aug. 20, '43). Morbidity and mortality reports indicate U.S. health not yet significantly affected by conditions incident to present war participation. Among other reports of disease, increased incidence of dysenteries noted during first half of '43. About 60% more cases shown to end of July than for same period last yr. Increase probably due largely to inadequate san. precautions in food establishments and carelessness among food handlers. Prelim. figures indicate new low in '43 for typhoid morbidity and mortality.—*Ralph E. Noble.*

Water Conservation. Methods of Double Use Employed by the Army. Anon. Sci. Am. **169:** 108 (Sept. '43). To curb wastage and provide most effective water use where supplies limited, Army engrs. studied several schemes. One resulted in design of communal lavatory for theater-of-operations cantonments in which waste water from wash trough and showers collected in tank and re-used for latrine flushing. All waste water drained to 1000-gal. concrete tank under lavatory floor. When full, automatic siphon discharges water through adjoining concrete pit latrine, outlet of which connected with camp sewer system. Dual water use for washing and flushing will save at least 10 gpd. per man, substantial amt. in large camp. Laundry waste-water reclamation also studied and estd. possible to save 10 gpd. per man. Treatment process involves segregating laundry waste from other waste, addn. of lime ppt., air flocculation and sedimentation.—*Ralph E. Noble.*

Uncle Sam: Water Boy for War-Boom Towns. Kenneth Markwell. Va. Munic. Rev. **20:** 135 (July '43). Uncle Sam carries water to war-boom towns throughout nation, making it possible for workers to remain at jobs in shipyards, munition plants, aircraft factories and other vitally important industries. Hampton Rds., Va., area one of most congested war-activity centers. '41–'42 droughts dried up streams and lakes in Tidewater, Va., reducing water supply in above area to dangerous low point, even for normal pop. Following co-op. efforts of Norfolk, Portsmouth and Newport News city officials and FWA, $12,000,000 water works improvement program nearing completion. Most important projects as to increased water supply and money: 31-mi. reinforced concrete pipeline from Chickahominy R. to Harwood's Mill and Lee Hall reservoirs supplying Newport News; 21-mi. similar conduit from Nottoway R. to headwaters of Lakes Prince and Cahoon, chief sources for Norfolk and Portsmouth; and second supply line from Lake Prince to Norfolk and concrete-earthfill dam to impound addnl. water at Lake Burnt Mills—subsidiary reservoir for pumping water to Lake Prince. Chickahominy R. supply line taps river near Walkers. Intake pumping station capac. 22,000,000 mgd. Shortly below station 1500′ low-head pile-concrete dam being built across river to prevent tidal salt-water from entering line. El. 4′ above mean sea-level. Fish ladder and 60′ lock included. Completed, 1700 mil.gal. salt-free water, will assure yr.-round water supply for towns and military bases on Lower Peninsula. Other lesser projects, improvements in Newport

News water system, Norfolk and Nottoway pumping stations and Suffolk-Portsmouth pipeline described.—*Ralph E. Noble.*

Is Water Vital? ANON. The Driller **17:** 9: 10 (Sept. '43). Office of War Utilities survey earlier in yr. disclosed water requirement of war plant communities along northern rim of Detroit would be critical in terms of available facilities. Difficulty, lack of pressure. OWU detd. it impractical to lay sufficiently large mains. Nearby Highland Pk. had 40-mil.gal. standby reservoir. Large mains of Detroit system close by. Highland Pk. agreed to rent reservoir to govt. Detroit agreed to supply Highland Pk. with necessary standby service. Philadelphia, agreed to lend 4 new 40-mil.gal. pumps being completed for own system. FWA agreed to finance and construct project. Equip. and service suppliers co-operated fully. WMC, U.S. Employment Service and labor unions supplied labor which resulted in 6-mo. job completed in 8 wk.—*Ralph E. Noble.*

Chicago's Water Endangered by Sewage in Lake Michigan. ANON. Eng. News-Rec. **131:** 169 (July 22, '43). Report of Oscar E. Hewitt, City Comr. of Pub. Works, states that poln. of South Side water supply, serving more than million people, rising steadily. During first 7 days of July, 11 of 15 tests showed coliform content considerably over danger point. Judged by U.S. Public Health Service stds., water supply so pold. that chlorination cannot completely control it. Repeated attempts to obtain permission to increase diversion from L. Michigan into San. Dist. Canal, Calumet R. and Sag Canal from 1500-cfs., limit set by U.S. Supreme Ct., to 5000 cfs., unsuccessful. Lake level now 0.79′ higher than yr. ago and increased diversion would lower level only 1″ first yr. and total drop, if such increased diversion continued, would be only 2″, according to Horace P. Ramey, Asst. Chief Engr., Chicago San. Dist.—*R. E. Thompson.*

No Emergency Action Required to Meet Chicago Water Needs. ANON. Eng. News-Rec. **131:** 309 (Aug. 26, '43). Report to President by Donald M. Nelson and Leland Olds states that exercise of emergency wartime powers to permit increased diversion through Calumet-Sag Channel neither necessary nor desirable. Report points out that priorities already granted for constr. of addnl. water facilities, that in meantime there is every reason for confidence that present chlorination facilities will be adequate, that any addnl. diversions found necessary will be for short periods only and can be compensated for later to keep within annual limitation and that, if latter impossible, appeal can be made to Supreme Court, which retains jurisdiction to modify decree governing diversion. Necessary tunnels and coagulation and sedimentation structures of new South Side purif. plant could be completed in time for service next summer, which will, it is believed, adequately safeguard public health in Chicago for duration. Also pointed out that poln. limit suggested in U.S. Public Health Service manual for production of safe water by chlorination refers only to simple chlorination, whereas in Chicago's South District double and superchlorination employed, under which conditions bacterial content of water supply does not seem to justify apprehension. Poln. so far this yr. less serious than for no. of yr.—*R. E. Thompson.*

Delaware Aqueduct Now Serves New York City. ANON. Eng. News-Rec. **130:** 465 (Apr. 8, '43). As emergency measure to safeguard New York's water supply from bombing attacks and sabotage, 42 mi. (2 sections) of 85-mi. Delaware aqueduct, longest bombproof tunnel in world, placed in limited operation 2 yr. ahead of schedule and bringing water into city from upstate watersheds heretofore tapped by vulnerable Croton and Catskill aqueducts. $290,000,000 aqueduct, 18′ in diam., drilled through solid rock and lined with concrete. It links Croton and Catskill watersheds and will eventually tap East Branch of Delaware R., connecting with city tunnel placed in service in '36. In places aqueduct, which will end for several generations recurrent water famines that have plagued city, more than 1000′ underground.—*R. E. Thompson.*

How Critical War Materials Were Saved at Atlanta. PAUL WEIR. W.W. & Sew. **90:** 6: 189 (June '43). Water Dept. of Atlanta, Ga., operates 2 filtration plants: 21-mgd. gravity plant 20 yr. old and 18-mgd. steel tank pressure plant 50 yr. old. Renovation of plants involved waterproofing all concrete surfaces and rustproofing laterals, manifolds, gate valves and tanks. Waterproofing and rustproofing accomplished with application of "No-Ox-Id." Waterproofing metal surfaces either flame-primed or sand blasted

Bronze surfaces on valves protected from sand blast by painting with "No-Ox-Id." Improvements resulted in ability of city to meet increased water demands with no increase in capital investment or acquisition of critical materials.—*F. J. Maier.*

Save Critical Materials by Softening Water. C. R. KNOWLES. Ry. Age **114:** 820 ('43). Large amt. of critical materials saved through systematic improvement of locomotive water supplies. Saving in fuel estd. at 8 million tons annually. Boiler defects caused by water reduced 64 to 87%. Wayside plants using partial treatment installed at low cost with good results. Proper blowdown control important. Estd. that 9 lb. of firebox and tube steel saved each yr. for each lb. required for initial installation of water treating plants. —*C.A.*

Wartime Improvement to a Rural Water Supply Scheme. ANON. Wtr. & Wtr. Eng. (Br.) **46:** 111 (Mar. '43). Dist., in common with most rural areas, supplied by long lengths of small-diam. pipe which carry relatively low flow. As "sluggish" c-i. pipe encrusts relatively quickly, intention was to use asbestos-cement or pipe with non-corrodible lining. Owing to war, main-laying program abandoned. As result of flow test decided to install pressure-control valve on 6" main, to erect 12,000 gal. (Imp.) steel tank on 40' tower, and to construct small emergency booster station.—*H. E. Babbitt.*

Water and Sewage Works Plants Are Extremely Valuable. ANON. Official Bul. N.D. Wtr. & Sew. Wks. Conf. **10:** 12: 3 (June '43). Nothing as valuable in water and sewage works records as accurate maps of water and sewer systems on which indicated all information as to sizes, grades, depth of bury, valve location, service connections, curb cocks, etc. In emergency, such information worth much money particularly in case of main break on cold day. If unable to find valve to shut off water until elevated storage completely drained and fire breaks out danger apparent. In many cases much of this information matter of water supt.'s memory only. Should be brought up to date in permanent form.—*Ralph E. Noble.*

Army Camp Water Supply Systems. JAMES GIRAND. Civ. Eng. **13:** 219 (May '43). Water requirements of theater of operations somewhat lower than those for mobilization type—about 70 gpd. per cap. Latest development in cantonments "field camp," designed for 50 gpd. per cap. Trend in airport design follows same pattern as cantonments. Consumption depends on facilities available and type of occupying troops. When housed in modern bldgs. with adequate facilities, consumption rises to 100 or 150 gpd. At one theater-of-operations camp, water and sewer systems governed site plan to unusual deg. Field-camp constr. introduced only recently. Dispersed-type air bases particularly interesting in that considerable ingenuity required for economic solution of problem of furnishing small quant. of water over extremely large area. Extremely high stds. of constr. of early cantonments not justified.—*H. E. Babbitt.*

Pure Water for the Forces. ANON. Wtr. & Wtr. Eng. (Br.) **46:** 192 (May '43). Among means for provision of water for army in field, mobile truck-trailer units of particular interest. Paterson pumping and purifying unit of 3000 gal. (Imp.) per hr. capac., comprising twin Stellar filters and chloramine injection plant, with gasoline engine and mono pump, all mounted on std. 15-cwt. trailer unit. Unit in extensive use in Tunisia and Middle East as well as for static installations at home and overseas. In addn. Stellar system applied extensively in form of smaller units of 200 gal. (Imp.) per hr. capac. for mounting on std. water trucks and also on tripods with hand pumps enabling pure water supply to be obtained for party of men from any watercourse, no matter how polluted.—*H. E. Babbitt.*

Portable Pipeline Hits Axis. ANON. Natl. Pet. News **35:** 31: 6 (Aug. 4, '43). New "front-line" pipeline for oil, gasoline or water consists of 4" flexible light steel 20' pipe sections, weighing 5 lb. per ft., easily lifted and carried by 1 man. Spiral welded with ends grooved for "Victaulic" couplings. Extreme flexibility permits hauling line by truck or trailer carrying pipe, couplings and pumps. Not needing trench, pipeline following terrain may be wrapped around trees, bent over hills or curved across streams without impairing automatic functioning. Easily handled by field crews. Pumping stations established at 10-mi. intervals. If one put out of operation, line capac. reduced only 30% during interval. Third of stations or any adjacent 2 may be out of commission and line still function.

Designed to operate between −40° and 130°. Total wt. of system per mi., including pumping stations, only 13 tons. Cost of material excluding transportation and labor, about **$3000** per mi.—*Ralph E. Noble.*

Fresh Water From Sea Water. ANON. Lancet (Br.) **244:** 667 (May 22, '43). Ministry of War Transport announced 3 types of stills for distg. fresh water from sea water. Commercially one produces ½ gal. per hr. Uses either solid fuel or paraffin, but designed to work with compressed coal briquettes supplemented by waste material or wood recovered from sea. Other 2 types under development are paraffin consumers with higher output in relation to fuel consumption.—*Ralph E. Noble.*

How to Drink Sea Water. *Herron's Safety-Stills.* ANON. Fortune **28:** 2: 68 (Aug. '43). Herron's safety-still called "blood bank of the seas," ranks high in eff., size and purity of distillate. Produces hot or cold water; equipped with grill for broiling fish and pressure cooker for prepg. dehydrated foods. Operates in usual fashion with hose immersed in ocean as condenser. Remarkable feature is fuel, gelled non-melting nonexplosive gasoline compound burning without liquefying to produce fire hazard. Generates 10,000 Btu.'s per lb more than comparable amt. of alc. and about as much as kerosene. Made in 3 sizes: 17¼ lb for lifeboats and large rubber rafts. Equipped with 19⅔-lb. fuel cans, will produce 142 lb. of water. 8 lb. for 4- to 12-man rubber rafts produces ⅔ qt. per hr. 4 lb. for 1- to 3-man rafts distills pt. of water with 0.1 lb. fuel.—*Ralph E. Noble.*

Wartime responsibility of Water Engineers. [S. H. W. MIDDLETON] Wtr. & Wtr. Eng. (Br.) **46:** 99 (Mar. '43). Author drew attention to risks of contamn. from air raid damage and poln. of catchment areas by evacuees and troops in training. Repair of air raid damage entailed heavy work on limited staff. Shortage and control of lead pipe difficult feature of water distr. Frequent inspection of residential area with high pressure proved unable to reduce waste below 17%. Quants. used throughout British Isles, for 57 mainly industrial towns over 50,000 pop., in England was 33 gpd.(Imp.) per cap., while for some Scottish towns of similar type was 52, and in Belfast was 42.—*H. E. Babbitt.*

STERILIZATION

Notes on the Control of Chlorination. A. R. VAIL. Surveyor (Br.) **102:** 225 (May 28, '43). River water normally of poor qual. and requires considerable treatment before it can be rendered potable. In its passage through soil and strata beneath, water receives natural purif., but depth not, *per se,* guarantee of purity. Under war conditions, some addnl. potential dangers: (1) military camps; (2) temporary bivouacs of troops on gathering grounds; (3) overloaded cesspools and small sewage disposal works; (4) sewers, in permeable strata, fractured by bombs; and (5) earth shock, from explosions, opening fissures. 4 systems of chlorination in general use today: (1) simple chlorination; (2) super-chlorination and de-chlorination; (3) chloramine process; and (4) post-ammoniation. With chlorine in doses up to 1 ppm., contact period of not less than 20 min. necessary for destruction of all bacteria. Most common method for making residual chlorine tests is ortho-tolidine comparator. For simple chlorination, aim should be residual of 0.2 ppm. After super-chlorination, with doses of order of 5 ppm., contact period of not less than 10 min. should be given before de-chlorination. With chloramine necessary to give contact period of 2 hr. before residual test applied. Addn. of ammonia after chlorination to convert residual chlorine into chloramine to prevent taste and to carry residual through supply system.—*H. E. Babbitt.*

Why Chlorinate Public Water Supplies? F. C. BEELMAN. Kan. Govt. Jour. **29:** 3: (Mar. '43). Chlorination, long considered essential for surface supplies, not received attention merited by many well-water supplies. When adopted, however, water supt. should not relax vigilance in protecting supply source and distr. system. He should consider it desirable as addnl. safety barrier, not as substitute for any or all protective measures. Properly controlled, chlorination will not cause tastes or odors. No med. evidence that disinfecting concns. of Cl for water will harm consumer. Much evidence, however, to show

consumer protected from water-borne disease. Outbreak of latter in city may assume catastrophic proportions comparable to flood, hurricane or aerial bombing. Chlorination costs insignificant as compared with benefits. New and repair work in water collection or distr. system should be disinfected carefully before placing in service.—*Ralph E. Noble.*

Emergency Chlorination. CHARLES M. DAVIDSON. Bul. Ky. Dept. Health **16:** 106 (Aug. '43). Variation in Cl content of different compds. requires much calcn. to det. dosage with given type. First to remember, 1 gal. of water weighs 8.34 lb. 1 ppm. Cl means 1 Cl unit in 1 million units of water. In lb., therefore, 8.34 lb. of Cl in 8,340,000 lb. of water (1 mil.gal.) gives 1 ppm. Cl. Percentage and ppm. not same; 1% soln. is 10,000 ppm. Layman seldom deals with pure Cl or large water supplies, but generally called upon to use Ca or Na hypochlorites in cisterns, reservoirs or small pumping equip. Hypochlorites in powd. or liq. form and sold as chloride of lime, HTH, Perchloron, CCH, Chlorox, Purex, Zonite, BK, etc. In using these, 1 gal. of 1% soln. will give 1 ppm. in 10,000 gal. This concn. higher than used for filtered water. Any org. matter present represents definite Cl demand. As Cl reacts readily with org. matter, residual Cl necessary to disinfect bacteria. Difference between amt. applied and residual by ortho-tolidine test is Cl demand, varying widely with different waters. When using above compds., always refer to label. Usually, latter will show % available Cl ranging from 1 to 70. To prep. desired soln. with 70% compd., necessary to use 1.4 times amt. required if pure Cl used; with 50% compd., twice as much needed. *Example.* To apply 1 ppm. soln., use 8.34×1.4 or 11.7 lb. of 70% compd. to 1 mil.gal. In case of 50% compd., use 8.34×2, or 16.7 lb. Various household bleaches (Clorox, Purex, Chlorite, etc.) about 5%; products for janitor use, about 14%. Higher percentages in powder form, stable Ca hypochlorites, such as HTH and Perchloron.—*Ralph E. Noble.*

Disinfectants for the Armed Forces. G. F. REDDISH. Soap & San. Chems. **19:** 8: 101 (Aug. '43). Aside from actual fighting equip. and food, germicides important item used. Cl and its compds. proved specially satisfactory for decontamg. drinking water. Na hypochlorite, chloramine-T and -B, halazone and others used. To give complete satisfaction Cl compd. must be designed to kill excessive nos. of disease germs in highly acid or alk. water from 36° to 120°F. within 10 min. Water thus treated must be clear, palatable and without unpleasant odor. Compd. should be non-toxic, available in large quants., stable under all storage conditions without special precautions and containers at high or low temps. and humidites for yr. or more. Tablet form more convenient and practical than powder or liq., requires less space and handling. Simple, quick and accurate dosage possible by adding 1 or 2 tablets to canteen in field.—*Ralph E. Noble.*

An Emergency Method for the Sterilization of Water. ARNOLD RENSHAW. Lancet (Br.) **245:** 237 (Aug. 21, '43). Iodine effective agent for sterilizing water against typhoid, paratyphoid, cholera and bacillary dysentery within 10 min. Expts. described. Should prove useful as emergency method by civilian pop. or isolated troops. [Method appears dependent upon filtering treated water through charcoal to remove excess iodine. Without such removal, dosage recommended suggests possible danger from iodine].—*Ralph E. Noble.*

The Stability of Sodium Hypochlorite Solutions Used in the Chlorination of Water. PAUL LANDOLT. Monatsbulletin (Swiss) **23:** 3: 52 (Mar. '43). NaOCl solns. can be used to advantage in chlorination of medium and smaller supplies. Prepd. by passing Cl gas into dilute NaOH soln., resulting compd. possesses a high disinfection value, practically odorless and safe to use. Not generally used, however, because of lack (until lately) of proper app. for application and unstable character of soln. itself. Results of various tests on keeping qual. given, made on NaOCl solns. contg. various percentages of active Cl; all contained excess of 10 g./l. uncombined NaOH. Solns. stored in green flasks and kept in dark. 4% available Cl soln. contg. 44 g./l. Cl, when stored at 9°C., lost no Cl in 3 mo., and but 1 g./l. in 6 mo.; at 19°C. loss in 1 mo., 1 g./l., 2 mo., 0 and 1 g./l. each mo. (up to 6) thereafter; at 29°C. loss first mo., 3.5 g./l. and 3.5 more second mo.; 4 g./l. lost in 1 mo. at 39°C. and 33 at 65°C. Loss in stronger solns. considerably higher—at 9°C. loss in 13% soln. in 1 mo. storage amtd. to 8 g./l. Cl and avgd. close to 7 per mo. thereafter; at 19°C. avg. monthly loss 15 g./l. and at 29°C. avgd. 45 per mo.

Similar figures for a 16% available Cl soln. 11 g./l. per mo. at 9°C., 24 per mo. at 19°C. and 70 per mo. at 29°C. At low temps. however, even concd. solns. quite stable; e.g., 16% soln., kept at 0°C. found to have lost but 5 g./l. Cl in 1 mo. Exposure to light found to have considerable influence on keeping qual., 4% soln. in white flask stored near window in sunlight lost 8.3 g./l. (approx. 20%) in 1 mo., while same soln. stored in green bottles in dark lost only 1%. Paint also proved good protection. Loss in painted container stored in sunlight, 1.1 g./l. Cl in 1 mo. (2.5%). In another test, a soln. contg. 5.6% available Cl stored in green bottles in unheated room in dark for period of 9 yr., loss of Cl, in g./l., for each of years of storage as follows (original soln. contained 61 g./l. Cl: 8, 5, 5, 3, 3, 3, 2, 2 and 1. Author concludes more concd. NaOCl solns. must be kept in cool places and used soon after prepn.; dil. (2%, 4% and 6%) solns. lend themselves to water treatment in that they keep well and are easy to handle. Such solns. should be kept as dark as possible and away from exposure to direct sunlight. 12% and more concd. solns. do not freeze at as low temps. as −18°C.; 4% soln. formed ice crystals at −5°C. but did not entirely freeze until −12°C.—*Martin E. Flentje.*

Some Factors Affecting the Germicidal Efficiency of Chloramines. George R. Weber. Iowa State Coll. J. Sci. **17:** 155 ('42). Spores of *Bacillus metiens* used for tests made. Killing time exposure in min. required to kill 99% of spores. When concn. of available Cl 22–24 ppm. as hypochlorite, killing times: 2.1–3 min. at pH 5–7; 7.6 min. at pH 8; 58 min. at pH 9; and 570 min. at pH 10. When 0.5 or 2 ppm. NH_3 added to buffered soln., effect same as decreasing concn. of Cl. When chloramines furnish 25 ppm. available Cl in presence of 6 ppm. NH_3, at pH 6–8 killing time 83–89 min. With chloramine to give 25 ppm. Cl and 6 ppm. NH_3 at 20, 30, 40 and 50°C., and pH = 10, $\log y = (-0.370) \log x + 2.334$, where y = temp. and x = killing time in min. Killing time decreased 60% for each 10°C. rise in temp.—*C.A.*

Investigations on Disinfection of Water With Ultraviolet Light. H. Thomsen. Milchw. Forsch. (Ger.) **21:** 125 ('42); Chem. Zbl. (Ger.) **1:** 3155 ('42). Low-pressure ultraviolet light app. used in lab. expts. for disinfection of water described. When 800 l. of water contg. *Esch. coli* and *Pseudomonas fluorescens* illuminated for 1 hr., 99.5% of bacteria killed; only 90% of spore-forming bacteria killed. Turbidities produced by adding skim milk or lime mortar to water had little effect on results. Disinfecting power of app. compared with that of h-p. ultraviolet app. and with heating to 85°C. With similar periods of radiation 2 types of ultraviolet app. about equally effective. Heating to 85°C., however, better method of disinfection as measured by no. of bacteria remaining alive. —*W.P.R.*

Bactericidal Radiation. A. R. Dennington. Am. Dyestuff Rptr. **31:** 16 ('42). Ultraviolet radiation between 2000 and 2800 Å bactericidal. Ultraviolet generators producing radiation of 2537 Å used in textile mills to reduce bacteria in water supply.—*C.A.*

Oligodynamic Action of Silver and Some Variables Affecting Its Action. Osvaldo M. Repetto & Fernando Modern. Rev. Inst. Bacteriol. (Argentina) **11:** 243 ('42). Pure water suspension of *Esch. coli* contg. 600 organisms per ml. requires only 0.000001 *N* concn. of Ag ion with 1-hr. exposure to inhibit totally subsequent development. Suspension contg. 3,000,000 organisms per ml. required 0.001 *N* concn. Presence of blood albumin or blood serum greatly decreased effectiveness of Ag ion. In presence of cryst. albumin, effectiveness of Ag decreased with increase in pH through range 3–9.—*C.A.*

Disinfection of Mains at Ottawa. Henry P. Stockwell. Can. Engr.—Wtr. & Sew. **81:** 8: 19 (Aug. '43). Portable chlorination equip. includes 300-lb. per day vacuum-type soln.-feed machine and single-cylinder, air-cooled gasoline engine with direct-connected water pump, whole being mounted, together with two 150-lb. Cl cylinders, on 2-wheel chassis constructed in dept.'s shops. Trailer body fitted with hinged top and removable side panels. During constr., all pipe lengths swabbed or sprayed with thin bleach whitewash and ends then protected with waterproofed canvas bags which remain in place until pipe ready for jointing. Completed main thoroughly flushed, filled with soln. contg. 100 ppm. Cl and allowed to stand at least 24 and preferably 48 hr. Sample for bact. examn. collected after flushing and second one 4 days after treatment, main being kept out of service until results satisfactory.—*R. E. Thompson.*

Chlorination of Well Water. D. Bartos, J. Bánsági & K. Bakos. Stschr. f. Hyg. u. Infektionskr. **124:** 2: 131 (Sept. 26, '42). 4 shallow wells dug through sand and gravel to depth of 4 m. Water rose in holes until about 1.5 cu.m. had collected. Water of good qual. chemically and bacteriologically. Expts. made in which water infected with cultures of *Salmonella typhimurium* (Breslau strain), *Eberthella typhosa*, *Shigella dysenteriae*, and *Esch. coli* and then treated with bleaching powder in doses of 0.6–2.0 ppm. available chlorine. Supplies of water drawn after intervals of min., hr., and days. Mud at bottom of holes also examd. after 1 day and subsequently up to several weeks. Bact. examn. of samples comprised direct plating of 1 or 2 ml. on agar or selective solid media, filtration of vols. up to 5 l. through Seitz filter and incubation of filter pad in enrichment bile media with subsequent subculture. Mud examd. by shaking up with water and then treating in same way as 5-l. vols. of water.—*B.H.*

WATER QUALITY

Amendments to State Sanitary Code. Health News Supplement, N.Y. State Dept. of Health **19:** 173 (Oct. 12, '42). Pub. Health Council of N.Y. State Dept. of Health, Sept. 25, '42, adopted amendments to Chap. V of State San. Code effective Jan. 1, '43. Amendments give closer control to state and local health officers over water supply operation such as requiring approval of new constr. and improvements, operating records, sample checking, reporting changes in pub. supplies and disinfection of new or repaired parts of a water system. Regulations for laying mains, governing cross-connections and use of dual supplies in hands of health authorities. Likewise, rules relative to pumping equip., protection of equalizing and distributing reservoirs given. Drinking water supplies in factories and other indus. plants come under direct control of local health officer.—*P.H.E.A.*

Protection and Chlorination of Public Water Supplies. N.Y. State Health Dept. Bul. No. 21 ('42). Purif. of pub. water supplies definitely reduced water-borne disease. Increased stream poln. and need to use such pold. water as source of supply makes effective purif. more difficult; requires technical control of treatment processes with vigilant inspection and supervision of watersheds to prevent further poln. Eff. operation requires trained operators of water purif. and treatment plants as well as suitable app. and equip. Character of supervision frequently more important than type of equip. available. Essential, therefore, that operators know theory underlying water supply protection and purif. Bul. particularly well compacted with technical information essential to efficient water purif. and treatment. Subjects discussed include: ground water; surface water protection and reservoir maint.; filtration *vs.* chlorination; Cl residual and flash tests; gaseous and soln. chlorination; emergency chlorinations; ammonia-chlorine treatment; superchlorination; record-keeping; cleaning and disinfection of new mains, reservoirs and tanks; taste and odor control; activated carbon treatment and cross-connections. —*Ralph E. Noble.*

Practical Steps to Improve Water Quality. Rene Cyr. Eng. Cont. Rec. **56:** 18: 20 (May 5, '43). Recommendations of Que. Ministry of Health regarding several water supply problems outlined. In one case, hydrant in hard ground found to be connected to sewer, rendering contamn. of distr. system possible. Another case dealt with involved cross-connection with indus. supply. Abandonment of munic. supply of Cap a l'Aigle, derived from Lapointe Creek, in favor of existing semi-public supply from springs recommended.—*R. E. Thompson.*

Chlorinator Installation at Nanaimo, B.C. Anon. Can. Engr.—Wtr. & Sew. **81:** 3: 23 (Mar. '43). Nanaimo, on Vancouver Island, will be first city in Canada to install new chlorination equip. in conformity with instructions issued by Dominion Dept. of Pensions and Natl. Health under authority of order-in-council of July '42, whereby minister and officials of dept. given power to provide for treatment of any supply which is meance to health of civilians engaged in essential war activities and of members of His Majesty's forces. Supply derived from 550-mil.gal. reservoir 15 mi. from city on mountain stream. Pipeline delivers water to 2 service reservoirs of 14 and 18 mil.gal. capac., resp., whence 2 parallel gravity lines—16″ wood-stave and 12″ c-i.—carry water to distr. system. Automatic visible vacuum chlorinator will be installed on each of latter pipelines. Dosage will be controlled by pressure differential across orifice plates inserted in lines. Pop. served is 9800—6600 within city limits. Consumption varies from 1.5 to 2.5 mgd.—*R. E. Thompson.*

Organization of the Water Division of the Office of War Utilities

By administrative order dated March 12, 1943, the Water Division of the Office of War Utilities was established.

On October 26, 1943, the Division was rearranged with respect to the functions of various sub-groups and the duties assigned to the individual staff members.

The Administrative Officers identified with the new organization are: Arthur E. Gorman, Director, Water Division; Daniel V. McCarthy, Executive Assistant; William D. Williams, Chief, Water Supply Section; Walter L. Leach, Deputy Chief, Water Supply Section; Harvey S. Howe, Chief, Materials Distribution Section; Newton B. Lyle, Deputy Chief Materials Distribution Section.

Abel Wolman and Llyod Nelson continue as consultants to the Water Division.

The principal contacts with water utilities will be developed and maintained by the Regional Engineers of the Water Supply Section.

The functions of the Water Supply Section are:

1. Obtain from federal agencies, the appropriate industries, and other sources, data bearing on requirements for water and prepare estimates of future requirements for water;

2. Ascertain and investigate the adequacy of water supply systems and water resources for meeting the above requirements;

3. Program the use of existing facilities, the interconnection of systems, and the co-ordination of operations of systems where such activities will provide greater availability of water;

4. Prepare program, recommend, and take the appropriate steps to develop the construction and installation of additional facilities necessary to correct inadequacies of existing facilities, with a minimum expenditure of critical materials;

5. Advise the Facility Clearance Board, Army and Navy Departments, other Divisions of WPB, and other planning agencies as to the availability of water at proposed locations for war plants or establishments; and

6. Work out arrangements with utilities for water service connections to major war industries.

The functions of the Materials Distribution Section are:

1. Analyze and recommend priority and allocations actions on applications for authorization of construction of water projects other than extensions to housing projects;

2. Process CMP forms covering allocation of controlled material for approved construction;

3. Follow up the approval of water works construction, and through appropriate actions assist in expediting

deliveries of materials and equipment to water works projects to assure their completion as scheduled;

4. Cooperate with the Equipment Production Branch of OWU in connection with its jurisdiction over manufacturers of water works equipment;

5. Maintain necessary contacts with other Industry Divisions and with manufacturers to assure an adequate supply of materials and equipment required for water works construction, operation and maintenance; and

6. Develop through co-operation with the Inventory Control Branch of OWU more effective use of water works material and equipment available to plant and in excess inventory of utilities and of other agencies.

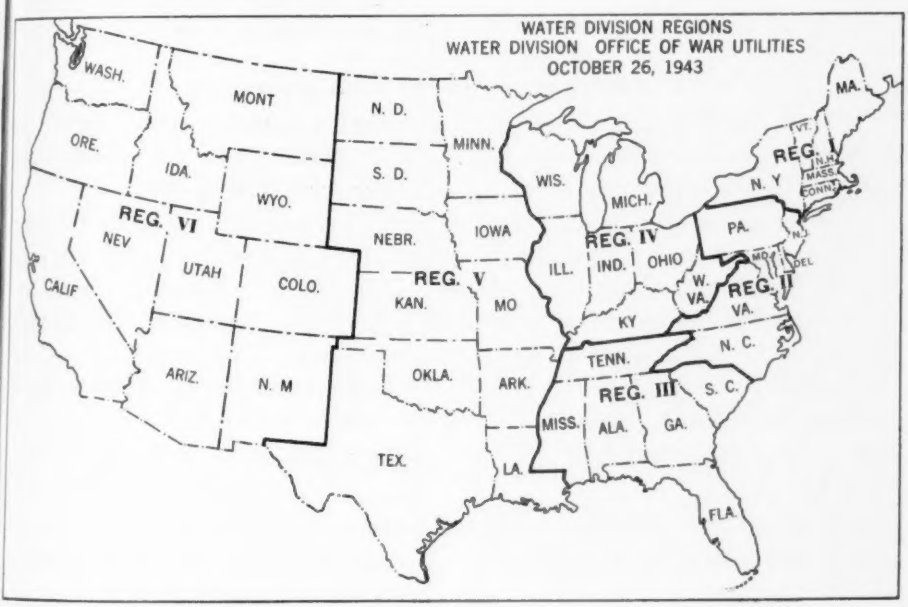
The new regional organization of the Water Supply Section will permit the development of closer relations between water utility operators and the Water Division. The regional engineer will co-operate with water utilities in connection with their problems of maintaining supply and service during the war for all essential military, civilian and war production needs. They will assist in developing necessary projects and after consultation with utility operators prepare recommendations as to materials and equipment which must be recommended quarterly to the WPB Requirements Committee for allocation. They will review all major projects applications from their respective districts especially as to relative essentiality. Effective October 20, assignments were made in that Section as follows:

Region I—New England and New York:

Regional Engr., *Bayard F. Snow*, formerly Cons. Engr., Boston.

Asst. Regional Engr., *J. Walter Ackerman*, formerly Chief Engr. and Supt., Consolidated Water Co., Utica, N.Y.

Region II—Pa., N.J., Md., Del., Va., N.C., and D.C.:



Regional Engr., *George C. Sullivan*, formerly Engr. with Blaw-Knox, Co., Pittsburgh.

Asst. Regional Engr., *T. L. Hudson*, formerly Senior Engr., U. S. Engr. Dept., Baltimore.

Region III—Tenn., Miss., Ala., Ga., S.C., and Fla.:

Regional Engr., *Carl W. Smedberg*, formerly City Mgr., Greensboro, N.C.

Asst. Regional Engr., *Howard S. Wakefield*, formerly Asst. Engr., Charles T. Main Inc., Kingsport, Tenn.

Region IV—Wis., Ill., Ind., Mich., Ohio, Ky., and W.Va.:

Regional Engr., *Frederick H. Weed*, Formerly Cons. Water Works Eng. practice with Allen Hazen, Geo. W. Fuller, and James H. Fuertes.

Asst. Regional Engr., *Robert L. McGrath*, formerly Engr., U. S. Dept. of Agric. Soil Conservation Serv., Washington, D.C.; prior to that Engr., Burns & McDonnell, Cons. Engrs., Kansas City, Mo.

Region V—N.D., S.D., Minn., Neb., Iowa, Kan., Mo., Okla., Ark., Texas and La.:

Regional Engr., *Ray B. Plummer*, formerly Asst. Chief Engr., Stuart-Warner Corp., Green River Ordnance plant, Dixon, Ill.

Asst. Regional Engr., *William J. Keays*, formerly Senior Conservationist, U. S. Indian Service, C.C.C. Division, Phoenix, Ariz.

Region VI—Wash., Mont., Ore., Idaho, Wyo., Calif., Nev., Utah, Colo., Ariz., and N.M.:

Regional Engr., *Gerald E. Arnold*, San. Engr., (R), U.S.P.H.S. under special assignment. Formerly, San. Engr., San Francisco Water Dept.

Asst. Regional Engr.—To be appoined.

With the exception of Mr. Arnold in Region No. 6, these engineers will have headquarters in Temporary R Building, Washington, D.C. Mr. Arnold will have his headquarters at the WPB District Office at 1355 Market St., San Francisco, Calif.

Emergency Aid for Coal Users

The Office of War Utilities has established a special service staff in its Fuel and Allocations Branch to assist water, electric, gas, etc. operators to obtain coal needed for operation during the current emergency.

Any water department or company which finds itself unable to maintain a safe suply of coal to operate its pumps, etc., should communicate with Mr. E. F. Stevens (Telephone—Washington, D. C. Republic 7500, Extension 5895. Address—Office of War Utilities, Temporary Building R, Room 2047, Washington, D. C.).

If a call is made, or a wire is sent, the following information must be at hand or included in the wire:

Company or department name
Territory served
Plants using coal—location, size
Rail or water delivery for coal
Equipment—type
Kind of fuel
Stocks on hand
Storage capacity
Monthly consumption
Required for (or use from) stock
Gross or net requirements
Suppliers

Instructions for Using Form WPB-2774

The instructions below are for guidance in the preparation of Form WPB-2774 which now replaces Forms PD-200, PD-200B, PD-1A, and CMP-4C, with minor exceptions explained in the instructions. Attention is called to the provision in the instructions relative to the preparation of project applications involving material costs of less than $10,000.

Form WPB-2774 appeared on page 979 of the July 1943, JOURNAL. *It is now being revised to a minor degree. The new form will be shown in the December issue.*

When to Use Form WBP-2774

Form WPB-2774 is to be used by Water Utilities when applying for (1) authority to begin construction, (2) for priorities assistance, or (3) for an allotment of controlled materials. It must be used for these purposes in connection with every water utility construction or installation which is not already specifically authorized under orders of the War Production Board. Applicants should familiarize themselves with the specific authorizations given them in orders and amendments of the U-1 series. Applications for projects involving construction of buildings not directly related to the production, transmission and distribution of water should not be filed on Form WPB-2774 but on Form WPB-617. Applications for water extensions to Housing Projects subject to the restrictions of Order L-41, shall continue to be filed on Form WPB-1290.

Form WPB-2774 is also to be used in applying for an amendment to a previously submitted application when the Water Utility is requesting:

1. An improved rating on one or more items previously authorized;
2. Additional or new items whether or not they require a rating and allotment of controlled materials;
3. Elimination of items whether or not they were previously rated and allotted controlled materials.

Form WPB-2774 should also be used when the water utility is requesting reconsideration of an application previously denied.

How to Prepare Form WPB-2774

Section A

Regardless of whether the application is being filed for new construction or installation, as an amendment to a previously submitted application, or for reconsideration of an application previously submitted and denied, Section A should be filled in completely with all pertinent information.

Section B—Description of and Necessity for Construction

The wide variety of water works projects makes it desirable to give the applicant the fullest opportunity to present in his own way information supporting his project. The information which the reviewing engineer

needs is that which any reliable water works engineer would submit in support of the proposed project.

Most water works projects can be classified under five major divisions: Supply—Pumping—Treatment—Storage—Distribution. The outline of information shown below will serve as a guide to the applicant in preparing data in support of a project. Information on only those items pertinent to the project being applied for need be submitted. If the applicant wishes to add substantially to the items covered in this outline he may do so. Where a project involves more than one of the above five divisions of water works certain basic data which may apply to all could be summarized in a special section of the applicant's report.

In the case of amendments to or reconsideration of previous application, any of the information in Section B submitted in the original application need not be re-submitted. The application should, however, refer to the original and give in detail the additional facts or representations on the basis of which the applicant requests an amendment or reconsideration.

Projects involving material costs of less than $10,000 can be justified by supplying the information called for in the seven questions at the bottom of page 1 using the blank space on page 2. If this blank page is insufficient to record all the supporting data then the applicant should furnish the information on supplemental letter size sheets.

Data regarding population to be served by a project and the quantity of water involved are necessary for all types of projects.

Where possible, important information as to the basis on which the hydraulic characteristics of a water plant are determined should be submitted. These include the size, length, location, capacity, elevation and characteristics of facilities requested. General location maps, including topographical features and important elevations, are needed for most projects. Profiles of pipe line and conduits with important sizes and elevations should also be submitted. Control factors used in design such as friction coefficients, rates of filtration, head and load curves for each hour on days of average and maximum use are useful. In cases where special meteorological factors such as rainfall, temperature, and evaporation are important to the projects, pertinent supporting data should be submitted. When practical, all maps and drawings submitted should be folded to letter size.

If the application is for an entirely new water system, it should be accompanied by a reasonably complete report on the proposed system, one similar in character to that which a consulting engineer would prepare for a client.

Suggested Outline of Data to Be Submitted in Support of Applications

I. General

a. Estimated present population

b. Estimated population upon completion of project

c. Water supply to system (million gallons daily)

	Present	*Upon Completion of Project*
1. Average day		
2. Max. day		
3. Max. hour		

Furnish records to substantiate above figures.

d. Percentage of water supplied by classes.

1. Domestic
2. Commercial
3. Industrial
4. Military
5. Unaccounted for

e. Number of services

	Metered	*Unmetered*	*Total*
1. Domestic			
2. Commercial			
3. Industrial			
4. Military			

III. Source of Supply

a. Ground Water Developments (discontinued, now in use, and proposed)

1. Describe developments with map showing location of each and relation to water system.
2. Description of aquifer and furnish logs of wells if available.
3. Safe yield.
4. Average withdrawal rate and hours of operation daily.
5. Sources of power.
6. Static water level including available records of changes.
7. Draw-down at various withdrawal rates.
8. Type, depth, and age of casing.
9. Type and capacity of lift.
10. Description of neighboring developments drawing water from same aquifer and their effect upon the water table.
11. Reason why discontinued sources cannot be put back into service.

b. Surface Water Developments (discontinued, now in use, and proposed).

1. Map showing location, size and topographical features of catchment area.
2. Storage capacity of lage or reservoir.—Available and potential.
3. Minimum, maximum and average stream flow.
4. Safe yield of source in MGD.
5. Rainfall records by years or months as recorded at nearest gaging station.
6. Evaporation factor used.
7. Water rights of others to source of supply.
8. Reason why discontinued sources cannot be put back into service.

c. Other systems (now in use and proposed).

If your supply is from another water system, furnish map indicating ownership, source, type of interconnection, amount of water to be obtained, frequency of use, pressure available, and capacity of other system to meet your demands.

d. Quality of raw water (usually obtainable from State Board of Health if not in your files).

	Yearly		
	Max.	*Min.*	*Average*
1. Temperature in degrees (f)			
2. Turbidity in ppm.			
3. Coliform organisms per 100 m. l.			
4. Total hardness as $CaCO_3$ in ppm.			
5. Chlorides in ppm.			
6. Iron as Fe in ppm.			
7. Manganese as Mn in ppm.			
8. Odor (indicate cause)—Character and Concentration			
9. Color (indicate cause)—Standard Units			
10. pH.			
11. Other qualities pertinent to the project.			

III. Treatment Plants

a. Plan of proposed project showing relation to existing facilities.

b. Description of treatments (in use and proposed).

c. Type, size, and capacity of existing and proposed treatment units.

d. Type and capacity of storage (existing and proposed).

e. If softening is proposed explain reasons for the degree of treatment.

f. Quality of water (If not furnished under 1. *Source of supply*).

IV. Pumping Facilities

a. Map showing locations of stations and their relation to system.

b. Hydraulic elevations pertinent to all pumping operations.

c. Type, size, capacity, speed and head characteristics of each pump (existing and proposed).

d. Type, size and speed of prime mover of each pump.

e. Purpose for which pump is used.

V. Storage Facilities

a. Map of existing and proposed facilities showing size, capacity, and elevations controlling hydraulics of system.

b. State whether elevated or ground storage, type of construction, kind of water to be stored, and operating elevations.

c. Describe normal operations affecting withdrawal from storage.

VI. Supply and Distribution System

a. Furnish map and profiles of supply, transmission, feeder and distribution mains pertinent to project, and including sizes, types and classes of pipe, location of valves and fire hydrants, and other important appurtenances.

b. Boundary lines of pressure zones and range of operating pressure in each.

c. Indicate consumer class of districts to be served, especially where principal demand is for fire protection.

Section C—Material requirements

For statistical purposes the materials and equipment required for a project should be grouped and properly described in column (a) under the following general classifications, each with its own heading:

1. Water Supply (includes collecting, storage and delivery facilities to treatment plant, pumping station or distribution system).
2. Treatment Plant.
3. Pumping Station.
4. Storage Facilities (in plant and distribution).
5. Distribution.

A project application may include more than one of the above classifications in which case the quantity of any one type of material or equipment used in the project should be pro-rated and listed under the proper group classification. For example, if a quantity of cast iron pipe is required for a project involving all five of the above classifications it should be distributed among the five group classifications on the basis of the quantity required under each.

All materials and equipment required for construction of the project should be described in column (a) and extended in columns (b) and (c) whether they require a rating or not.

Similar materials differing as to form or use should be described and listed separately. For example, steel should be listed as structural shapes, reinforcing rods, plates, bars, etc.

Copper should be listed as sheets, bars, rods, wire, etc.

Quantities of materials should be reported in terms of weight. Equipment should be adequately described by make, size, type, capacity and manufacturing catalog number. The quantities of equipment should be listed by units.

A rating is necessary for all materials and equipment the purchase of which requires a preference rating including materials and equipment to be taken from minimum inventory and which are to be replaced.

It is important that a delivery date be given in column (e) for each item of material and equipment on which a rating is requested in order to provide proper scheduling and delivery as required.

Quantities listed in column (f) should be on the same basis as those given in column (b). An X should be placed after each item in column (f) for which an allotment is to be requested in Section D.

Section D—Allotment of controlled materials

The WPB-2774 application form provides for a statement by the utility of the amounts of controlled materials on which a CMP allotment is necessary. The previous procedure, which required preparation by utilities of Form CMP-4C after receipt of the project authorization, is no longer necessary.

In some cases the applicant may expect to withdraw the controlled materials required for a project from his practical working minimum inventory and replace them in a subsequent quarter. In such cases the quarter indicated in Sections C and D is the quarter in which delivery will be authorized.

The applicant should include in the list of controlled materials for which an allotment is requested any controlled materials required by his contractor on a construction project or required by the manufacturer of a CMP Class A product used for the project. Information as to the gross weights of controlled materials required by the A product manufacturer and the quarters in which he will require delivery can, in most cases, be obtained from the manufacturer.

Any increase or decrease in the quantity of controlled materials required for a project previously authorized must be reported by filling an amended application on Form WPB-2774 requesting authorization for the change.

Allotments are made to applicants on a quarterly basis. The allotment number indicates the quarter in which delivery is to be made. Authorized controlled materials orders to mills, warehouses or distributors should indicate the *month* in which scheduled for delivery.

An allotment is valid for any month of the quarter for which it was authorized provided it is not used to schedule delivery earlier than required. If it becomes necessary to use the allotment number for delivery of controlled materials in a quarter other than that authorized, application must be made to the Office of War Utilities for the change.

We are Doing This for Uncle Sam

THE Use Water Usefully program which the A.W.W.A. is promoting, is a the request of the Government and in co-operation with the WPB.

We wish to thank our members for their loyal response and their encourag ing support of our efforts, and we would like to hear from all of you how yo like the Book, and what you think of Willing Water.

Shown on the opposite page is a mailing piece from *Water Conservation* This item can be ordered from the A.W.W.A., as an advertisement for use i your local newspaper, in sizes 3-col. or 4-col.

If you are interested in a cut of the faucets for use on postcard mailings we can supply the line of four faucets, with three-line heading and statistic below, in 3½ in. x 6 in. size; or, if you prefer, you can order only the first thre of the faucets, without the heading, but with statistics below, in a size approxi mately 2 in. x 4¾ in. You may want only one of the faucets with figures below size 1½ in. x 2 in. to fill a small space, and if so we will supply you with a cu of any one of the faucets.

How About Posters?

The three-color posters are attracting attention. Used in windows, o billboards, or in public buildings, they tell the story of *use water usefully*. Hav you asked your large customers about ordering some of the posters to promot the idea that their employees use all the water they need, but need all they use If you have not, why not ask your industrial and commercial accounts abou making use of one or more of the posters?

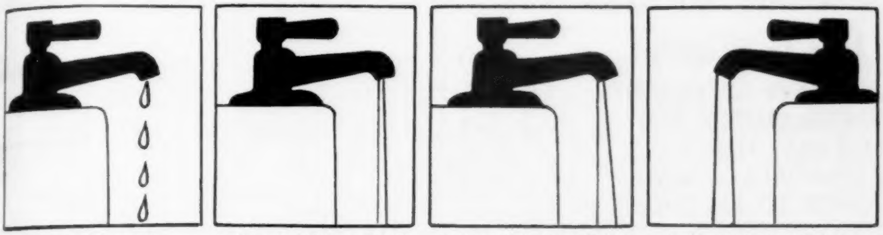
Remember that all six of the newspaper advertisements illustrated in th book *Water Conservation*, have been set up for your use as posters. These ar available in 4-col. (8 in.) size, on white coated stock at $20.00 for 500, or $30.0 for 1000.

Please send your orders in promptly, so there will not be too great a delay in shipment. Send all orders to the American Water Works Association, 50 Fifth Avenue, New York (18) N.Y.

YOUR UNCLE SAM WANTS WATER WASTE STOPPED

Because

WATER IS NEEDED TO BUILD WAR MACHINES



SLOW DRIP	1/32 INCH LEAK	1/16 INCH LEAK	1/8 INCH LEAK
15 gallons per day	165 gallons per day	650 gallons per day	2,520 gallons per day
105 gallons per week	1,155 gallons per week	4,550 gallons per week	17,640 gallons per week
5,475 gallons per year	60,225 gallons per year	237,250 gallons per year	919,800 gallons per year

Here Is How You Can Help Stop Waste

1. **Check all water outlets from attic to cellar.**
2. **Watch hot water faucets particularly. Hot water gaskets are affected by heat.**
3. **Check flush tanks of toilets. Place laundry bluing in the tank. If there is a leak the water in the bowl will be colored. Try this more than once; leaks are sometimes intermittent.**
4. **Don't leave the garden hose turned on over night. Each time it is used turn the spigot off.**
5. **Check waste in public washrooms of industrial plants, railroad stations, city recreation rest rooms; hotels.**
6. **Whether residential, commercial, municipal or industrial customer, check for leaks; stop waste; repair leaks immediately. TURN IT OFF.**

NAME OF WATER UTILITY

All over the Nation Uncle Sam asks Water Customers to Stop Water Waste

Co-operation from Spartanburg

Below is shown both sides of a postcard that was sent out to customers of the Spartanburg Water Company, Spartanburg, Pa., which tells the story of Use Water Usefully in small space. Note that the statistics used are based on 40 lb. pressure, and therefore differ from those used in the book *Water Conservation.*

WAR INDUSTRY NEEDS WATER!

Use It Wisely!

WE HAVE SUFFICIENT WATER SUPPLY, BUT IT TAKES FUEL — CHEMICALS — MAN-POWER TO PRODUCE IT! —

USE WATER ECONOMICALLY AND BUY BONDS WITH THE DIFFERENCE. —

DON'T BE A DRIP!

THANK YOU FOR COMPLIANCE

—

SPARTANBURG WATER WORKS
COOPERATING WITH
War Production Board

Address

1c STAMP HERE

How Water Is Wasted

Few people are aware of the large quantity of water that will flow, under pressure, through very small openings. The accompanying figures give this information.

DISCHARGE IN GALLONS PER HOUR

½	1,350 Gallons
¼	375 Gallons
⅛	150 Gallons
1/16	30 Gallons
1/32	7½ Gallons

40 Lbs. Pressure

Based on Only 40 Lbs. Pressure

This size stream from a ½ inch opening will flow 180 cubic feet per hour, or 1,350 gallons per hour.
In one month 972,000 gallons
Cost of waste @ 25c per 1000 gal. $243.00

This size stream from a ¼ inch opening will flow 50 cubic feet per hour, or 375 gallons per hour.
In one month 270,000 gallons
Cost of waste @ 25c per 1000 gal. $67.50

This size stream from a ⅛ inch opening will flow 20 cubic feet per hour, or 160 gallons per hour.
In one month 108,000 gallons
Cost of waste @ 25c per 1000 gal. $27.00

This size stream from a 1/16 inch opening will flow 4 cubic feet per hour, or 30 gallons per hour.
In one month 21,600 gallons
Cost of waste @ 25c per 1000 gal. $5.40

This size stream from a 1/32 inch opening will flow 1 cubic foot per hour, or 7½ gallons per hour.
In one month 5,400 gallons
Cost of waste @ 25c per 1000 gal. $1.35

COMPLIMENTS OF SPARTANBURG WATER WORKS

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STAMP
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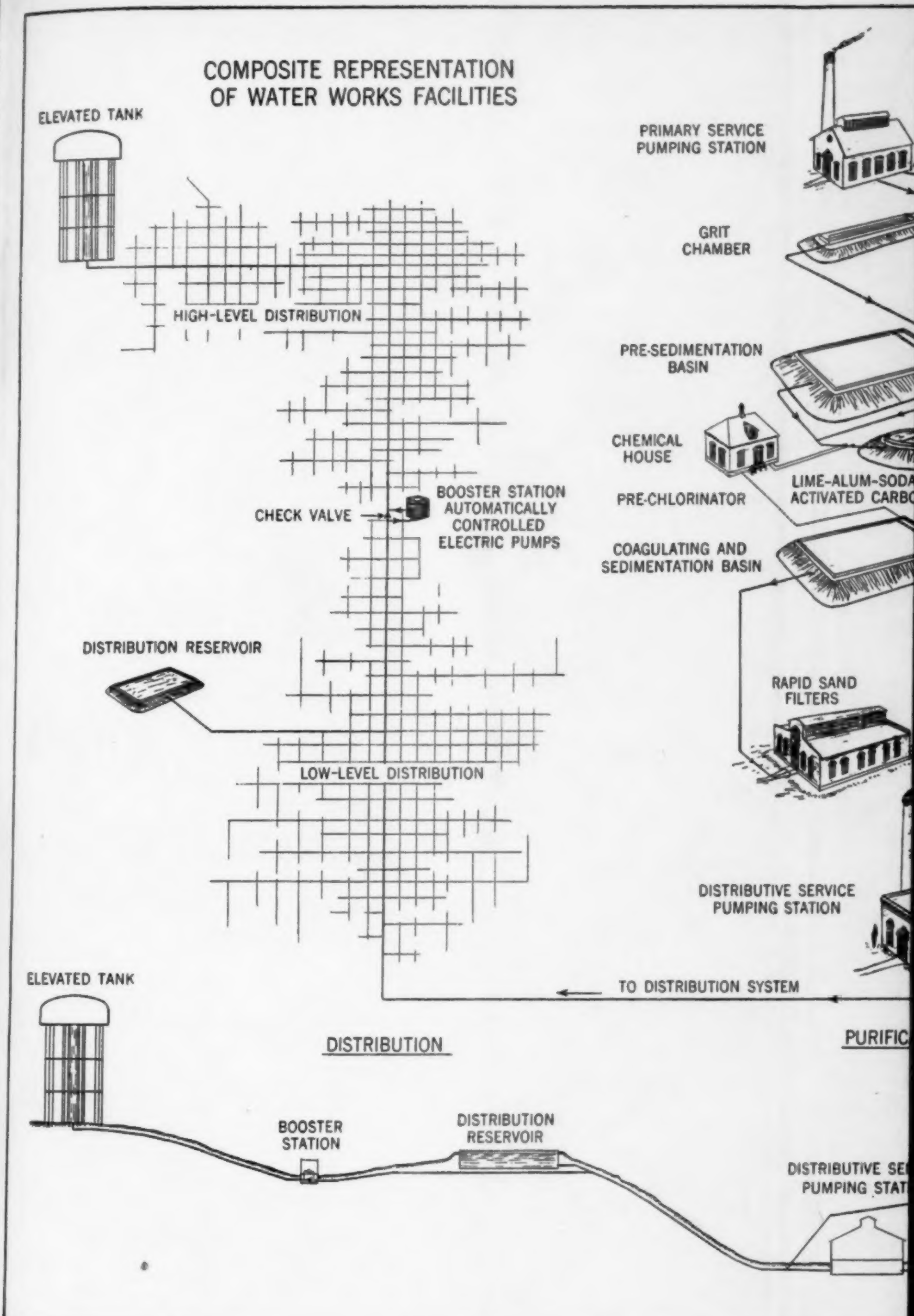
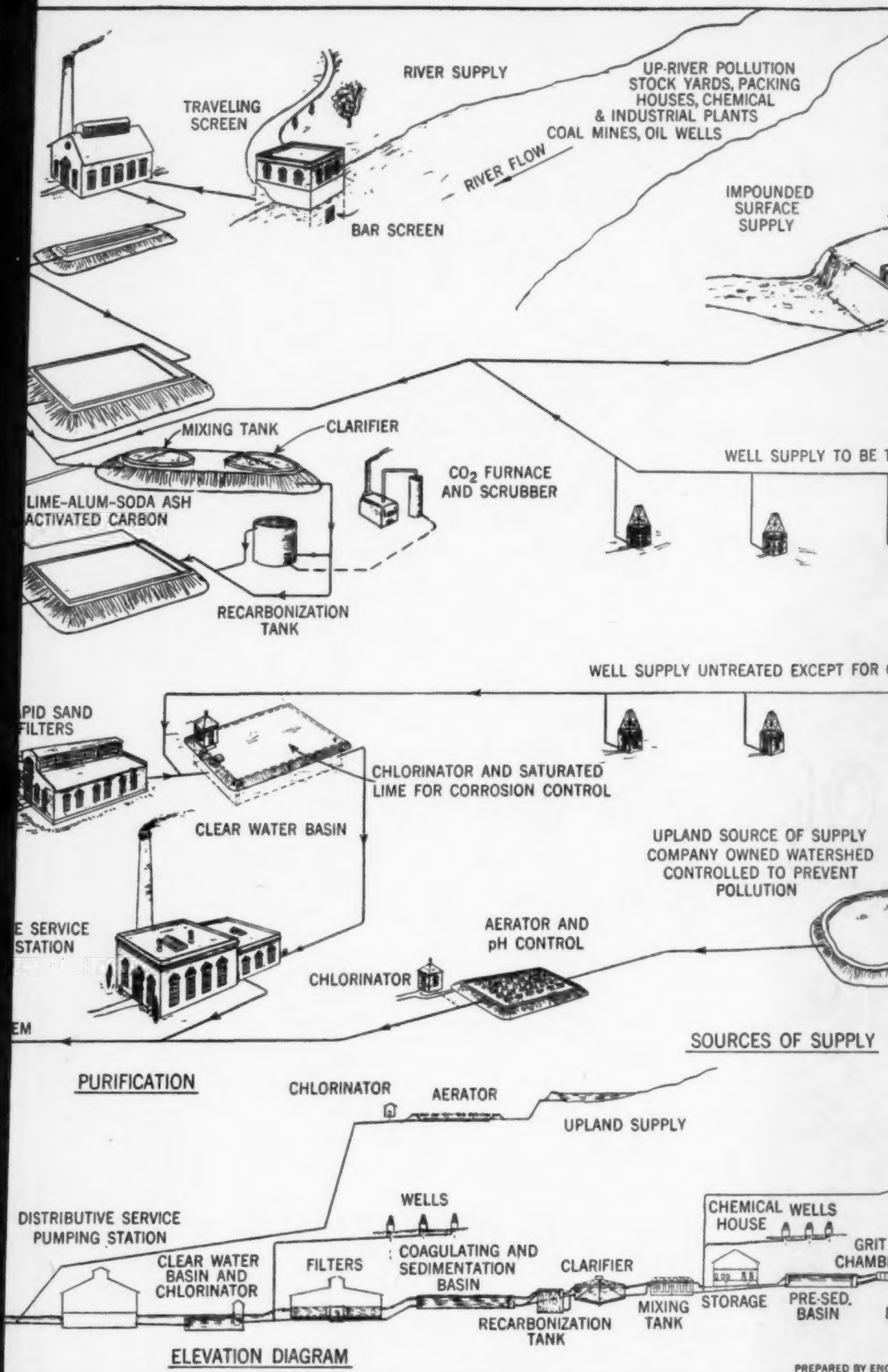
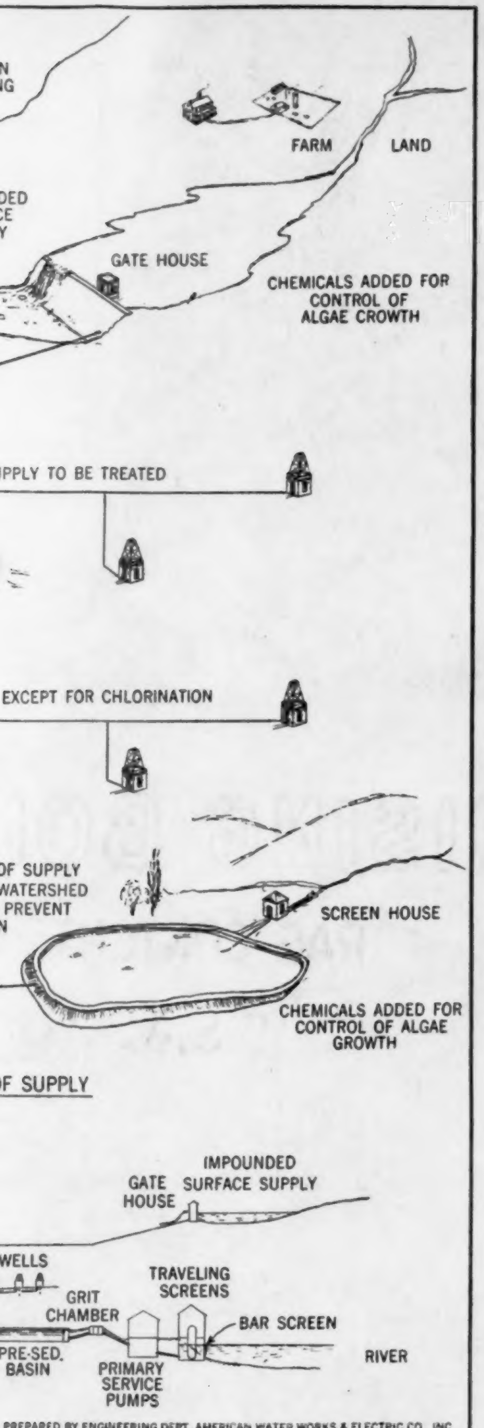



RIVER SUPPLY
TRAVELING SCREEN
UP-RIVER POLLUTION STOCK YARDS, PACKING HOUSES, CHEMICAL & INDUSTRIAL PLANTS COAL MINES, OIL WELLS
RIVER FLOW
BAR SCREEN
IMPOUNDED SURFACE SUPPLY
MIXING TANK
CLARIFIER
CO_2 FURNACE AND SCRUBBER
WELL SUPPLY TO BE T
LIME-ALUM-SODA ASH
ACTIVATED CARBON
RECARBONIZATION TANK
WELL SUPPLY UNTREATED EXCEPT FOR
PID SAND FILTERS
CHLORINATOR AND SATURATED LIME FOR CORROSION CONTROL
CLEAR WATER BASIN
UPLAND SOURCE OF SUPPLY COMPANY OWNED WATERSHED CONTROLLED TO PREVENT POLLUTION
E SERVICE STATION
AERATOR AND pH CONTROL
CHLORINATOR
EM
SOURCES OF SUPPLY
PURIFICATION
CHLORINATOR
AERATOR
UPLAND SUPPLY
WELLS
DISTRIBUTIVE SERVICE PUMPING STATION
CHEMICAL HOUSE
WELLS
GRIT CHAMB
CLEAR WATER BASIN AND CHLORINATOR
FILTERS
COAGULATING AND SEDIMENTATION BASIN
CLARIFIER
RECARBONIZATION TANK
MIXING TANK
STORAGE
PRE-SED. BASIN
ELEVATION DIAGRAM
PREPARED BY ENG



This "Composite Representation of Water Works Facilities" was developed by the Engineering Dept. of the American Water Works & Electric Co., to be used in connection with its public relations program. It is presented here through the courtesy of that concern.

This over-all schematic diagram may be used as a guide and inspiration for developing a specific diagram to fit any water works in presenting its story to its consumers.

Additional copies of this sheet can be purchased from the A.W.W.A. at 10 cents each—to cover cost of handling and mailing.